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Vol. 10 — NOVEMBER, 1929 — No. 11

CONTENTS

AGRICULTURAL ENGINEERING

Vol. 10 NOVEMBER, 1929 No. 11

Engineering Applied to Agriculture[1]

By H. B. Walker[2]

Engineering in agriculture relates to the engineering problems of an industry. In this respect it is similar to mining engineering, but in practice it must differ, since the basic sciences in agriculture are largely biological. For this reason an appreciation by the engineer of the importance of the biological sciences is essential.

Engineering in agriculture has attained great impetus in the United States through the extensive use of mechanical power. This has influenced the urban and rural population ratios. In colonial days more than 90 per cent of the people were directly dependent upon agriculture in contrast to 24 per cent today.

There have been three distinct power epochs in the agriculture of this nation: (1) Human, (2) animal, and (3) mechanical. The first was characterized by hard work and little social progress for the worker. The second marked the beginning of the machinery age in agriculture, resulting in the breaking down of tradition and the beginning of scientific agriculture. The third period, just beginning, is exerting a great influence on production methods as well as on the social environment of the worker. It is distinctly an engineering epoch.

H. B. Walker

Animal power reached its peak of application in the United States about 1918. The rate of decrease in such power is rapid, amounting to practically 500,000 animals per year.

Agriculture is becoming mechanized rapidly. Statistics in the United States show that, in 1924, 16 billion horsepower-hours were used by farmers, 16 per cent of which was supplied by steam and gas tractors. In 1928, 18 billion horsepower-hours were utilized, 28 per cent of which were supplied by steam and gas tractors. The total number of farm tractors in 1924 was 450,000 increasing to 768,825 in 1928. Similar trends in agricultural power are taking place in Canada, Argentina, Australia and British South Africa.

Agricultural engineering is fostered by land grant institutions. Thirty-seven of forty-eight agricultural colleges in the United States provide agricultural engineering training to 5,000 agricultural students annually. Technical engineers for this field are trained in seventeen of these institutions. Research work in this field is conducted by 103 full-time workers in thirty-four institutions.

The general acceptance of mechanical power by farmers has stimulated new ideas in equipment design such as automatic operations. Trends in tractor design show greater fuel economy, less weight per horsepower, greater field speeds and greater efficiency in transmission of power. Diesel engine tractors are gaining recognition.

Mechanical equipment has reduced the preharvest labor requirements for cotton production from 75 man-hours to 10 man-hours per acre. Similar savings are shown for corn and small grains.

Engineers experience trouble in getting agricultural machinery requirements expressed in tangible values useful in design. Tillage which consumes from 25 to 40 per cent of all agricultural power can not as yet be effectively measured or expressed in engineering terms or values.

The application of electricity to agriculture has opened up new engineering opportunities. Public utilities in the United States now have over 400 men specializing in rural problems. Many new uses have been developed.

Engineers in the rural structural field find it difficult to apply technical analysis to farm structural design because of rapid economic changes and lack of tangible values for farm management requirements.

The reclamation field includes drainage, irrigation, soil conservation, dry farming and land clearing. The potentialities of this field are great but development must be based upon economic necessity.

Engineers have an attractive but undeveloped field in agriculture in which they have an opportunity to render a great service to mankind.

ENGINEERING has been broadly defined as the practical application of science and scientific methods to industry. Accordingly, agricultural engineering may include the practical application of science and scientific methods to the industry of agriculture. In this respect it is not unlike mining engineering since it relates to the engineering in a specific industry, but in practice it is essentially different, since the basic sciences in agricultural production are biological rather than physical. Engineering in agriculture, as elsewhere, is concerned primarily with the physical sciences, but in the application of these sciences to production an appreciation of the relationships of the biological sciences is essential. Just as the sanitary engineer is interested in the work of the bacteriologist and the pathologist, so the agricultural engineer is concerned with the work of the botanist, plant pathologist, agronomist, and other scientists. It is not the function of the engineer in agriculture to do the work of these essential scientists, but rather his efforts, to be effective, must be complimentary in service to the industry.

Engineering in Agriculture in the United States. Engineering in agriculture has attained greater impetus in the United States than in any other single nation of the world. The reason for this is probably the product of a group of factors of a more or less complex economic character. Its growth has been closely associated with the industrial development of the Nation, but in all probability it is not a direct product of this development.

The United States has always been an agricultural nation. In the earlier colonial days the people were agricultural with more than 90 per cent of the population directly dependent upon agriculture for a livelihood. In 1928 fewer than 24 per cent of the population were directly dependent upon the industry for a living, yet the nation still is agricultural, and it produces a surplus of agricultural commodities. The production of raw products for food, shelter, and clothing is the chief function of the

[1]Paper presented before the World Engineering Congress, Tokio, Japan, October, 1929.

[2]Professor of agricultural engineering and agricultural engineer of the experiment station, University of California. (Official representative of the American Society of Agricultural Engineers at the World Engineering Congress.) Mem. A.S.A.E.

agricultural industry. At any rate this is the principal work of the rural dweller where engineering has found a place in production.

Power in Agricultural Production. Power in some form is required for all classes of production, and since agriculture is concerned with the production of basic commodities, the development of a nation can not be entirely disassociated from its agriculture and the type of power utilized in farm production. The power phases of agricultural progress are of particular interest to engineers, for the application, control and use of power in production are fundamental phases of engineering practice. As agriculture in the United States is now constituted this is very important, since from 40 to 80 per cent of the total cost of crop production consists of power and labor, factors in which engineering may be applied to advantage.

The Power Epochs in American Agriculture. American agriculture may be said to have had three power epochs: (1) Human, (2) animal, and (3) mechanical. These have an interesting correlation to the percentage of the total national population engaged in farm production. These relationships are shown graphically by Fig. 1.[3]

Human Power. The human power epoch continued until about the middle of the eighteenth century. In its general characteristics it is similar to that of other nations, being characterized by a relatively large percentage engaged in farm labor. During this period from 75 to 95 per cent of the people were required to produce the food supply of the nation. Furthermore, the work of the farmer was characterized by drudgery and monotony which no doubt contributed also to the encouragement of slavery. It is doubtful, if no substitution for human power had been developed, whether fewer than three-fourths of the population could have provided the necessary agricultural commodities for national stability. In other words, the optimum efficiencies of hand production methods would permit but one non-agricultural worker for every three persons gainfully employed in agriculture. This period in agriculture was of necessity slow in scientific and social progress.

Animal Power. Near the middle of the nineteenth century important changes were evident in the industry. The plow was in general use and improved harvesting devices were entering the practical stages of development. The hand methods which characterized the industry up to this time were gradually giving way to machine methods. In fact 1850 marked the beginning of the machinery age in American agriculture. The ingenuity of the inventor was stimulated through the utilization of animal power. This, then, was the beginning of the animal power epoch in production.

[3]Data on population obtained in part from Yearbook of Agriculture, U. S. Department of Agriculture, 1927, table 518, page 1170.

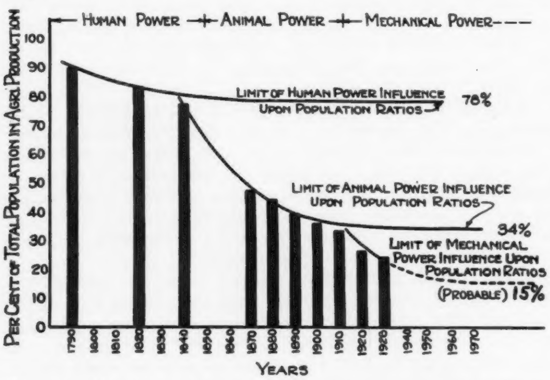


Fig. 1. Diagram showing relationship between percentage of total population engaged in agricultural production in the United States and the type of power utilized

The animal power epoch was characterized by a decided decrease in the percentage of population directly dependent upon agriculture for a livelihood. The maximum effect on population shifts was attained early in the twentieth century, probably about 1910, when only about one-third the population was directly dependent upon farming. This period in agricultural development was distinctly the achievement of the inventor and skilled mechanic. The farm of this time produced its own power plant and the fuel (feed) it consumed. The inventor and mechanic (the fore-runners of the engineer) applied their skill and ingenuity to the design and construction of machines best adapted to animal power, the chief incentive for machinery design being to overcome man labor by the substitution of animal energy. The farmer under this new regime being relieved of much of the monotony and drudgery of field operations, looked for better methods of production through crop improvement and tillage practices. It was in this epoch that scientific agriculture was inaugurated. The Morrill Act passed by the Congress of the United States in 1862 established land grant colleges, which formed the nucleus of the well-known state and federal agricultural experiment stations.

The radical changes in agricultural methods had a decided economic influence upon the Nation. Overproduction in raw products became a problem. There was a surplus of farm products and a period of small or no profits which stimulated a rapid migration to urban areas where the manufacturing and transportation industries were rapidly developing. This epoch of animal power utilization made it possible to support approximately two urban workers for every farm worker, but this ratio approached its maximum limit early in the twentieth century. Fig. 1 indicates that the maximum efficiency in animal power application was attained about 1910, although the period from 1910 to 1920, due to the World War, was one of extensive and efficient use of animal power in American agriculture. By this time machinery suitable for animal energy had reached its maximum size for efficient handling, and, moreover, the value of the crops used to produce such energy was great enough to call for the exploration of other suitable forms of agricultural power. Furthermore, there was a social demand for a more convenient and flexible power

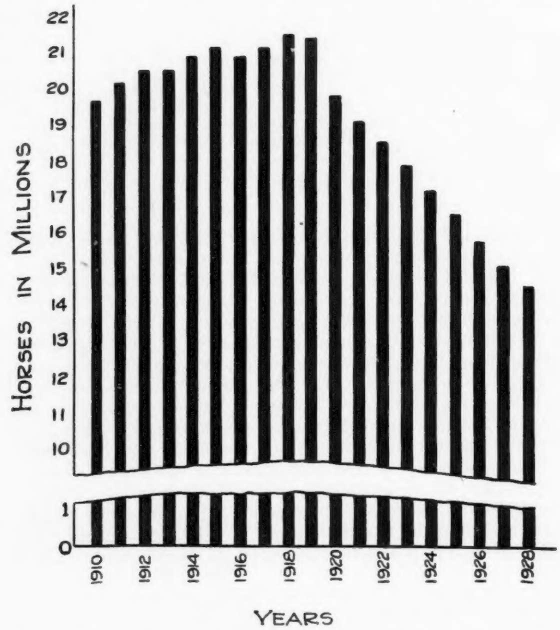


Fig. 2. Diagram showing the decrease in horse population in the United States

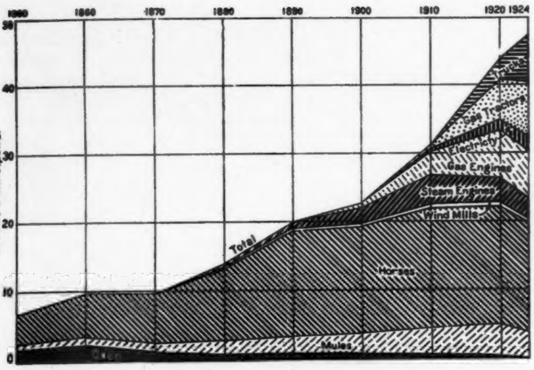


Fig. 3. Estimated total primary horspower available on farms of the United States from 1850 to 1924, inclusive. (Courtesy of the U. S. Department of Agriculture.)

in rural districts. Animal power, while revolutionizing field methods of production, failed to contribute directly to improvement in the conduct of domestic duties in rural areas, since it could not be readily adapted to household or farm chore work. This epoch, however, was a period of great significance in American agriculture. It marked the breaking away from the century old traditions in crop production, and it was the logical fore-runner of the mechanical power epoch which, after all, was the beginning of engineering applications to agriculture.

Mechanical Power. Although mechanical power was utilized on the farms of the United States as early as 1870, such power had no appreciable influence on production previous to 1910 and no marked economic influence until after 1920. Wind and steam power were utilized by farmers for pumping and threshing, respectively, soon after 1870. The former, although extensively used in the prairie sections, represents a relatively small total of primary power. The steam engine reached the peak of its application about 1910. The internal-combustion engine came into agricultural use about 1890, first for stationary power work and later (about 1910) for drawbar work and transportation. Electricity was used in a very limited way as early as 1900, but it did not attain importance as a source of farm power until after 1920. Thus mechanical power has been ushered gradually into the agricultural industry.

All of these forms of energy, except perhaps wind power, have been rather reluctantly accepted by the farmer. Accordingly, such power has often represented excess primary power for the first ten or more years after its introduction, and, as such, it had no appreciable effect upon the industry from an economic standpoint. The mechanical power epoch in agriculture was really initiated during the last quarter of the nineteenth century, although it did not become effective until after 1910. Fig. 1 indicates the relationship existing between this mechanical epoch, which as yet is only well started, and the ratio of population engaged directly in agriculture. The utilization of mechanical power has made it possible to further reduce the percentage in agriculture so that now three persons may be engaged in other industrial pursuits for every one in this industry. This tendency is still downward. It is difficult to forecast accurately the future from the data available, but there appears to be no great engineering obstacles in the path of further downward trends, so that by another quarter of a century of power development it appears likely that in America, at least, there should be no less than five industrial workers in other lines for every agricultural worker. Even greater achievements are within the realm of possibility.

The Effect of Power Changes on Production. The effect of this power change upon production is shown by index numbers in Table I, with the average for the period 1910-14 taken as 100.

TABLE I.
Index Numbers of the Mass of Crop Production[4]
(Average of 1910-1914=100)

Year and Period	Production Index Total	Per capita
1890-1894	62.0	90.6
1895-1899	78.0	104.0
1900-1904	84.5	101.8
1905-1909	94.0	102.8
1910-1914	100.0	100.0
1915-1919	108.0	99.6
1920-1924	110.0	95.4

From Table I it is apparent that the transition from animal to mechanical power is taking place with no loss in total production and at practically no sacrifice in per capita production. In this connection the following taken from the 1927 Yearbook of Agriculture of the U. S. Department of Agriculture (page 8) is significant as illustrating the recent tendencies in production:

> "From 1919 to 1924 there was a decrease of 13,000,000 acres in crop land in the United States—the first decrease ever shown by census statistics in the agricultural area of the Nation. There occurred at the same time a decrease in the number of farm animals, a decrease in the number of farms, and a decrease of farm population. Under such circumstances one would hardly expect an increase in the volume of farm production. Yet an increase took place, and a very substantial one. It is estimated that crop production in the period 1922-1926 was nearly 5 per cent greater than in the period 1917-1921, although the aggregate acreage in crops decreased slightly. Likewise the output of animal products is estimated to have increased fully 15 per cent. The increased productivity of the farm worker is estimated at about 15 per cent. This increase in labor efficiency, probably never before equalled, is attributable in part to the utilization of more productive livestock and crops, in part to the increased use of machinery and power on the farm."

The Decline in Animal Power. That the animal power epoch in American agriculture has definitely passed its peak of application is indicated quite strikingly by Fig. 2[5], which represents graphically the trends in the horse population of the United States for the period 1910-1928. The peak of animal utilization came in 1918, but since that time the number of animals has decreased each year at a very uniform rate, this being about 500,000 per annum. If this rate should continue, the horse for agricultural power in America will soon disappear. While it is apparent that animal power is destined to decline in importance, it is not likely that it will be entirely eliminated as a source of farm energy for many years.

Primary Power in Agriculture in the United States. Fig. 3[6] shows the trend in primary power for agriculture in the United States from 1850 to 1924. The sharp increase in mechanical power since 1910 is noteworthy. The total primary horsepower available for agriculture in the United States is not far from 50,000,000. Data compiled in 1924[7] showed that 16,000,000,000 horsepower-hours were utilized by the industry that year. Of this total 1,600,000,000 were supplied by gas tractors and 1,000,000,000 by steam tractors. The total number of tractors was estimated at 450,000. In 1928[8] it was estimated that the farmers of the United States utilized 18,100,000,000 horsepower-hours. Of this total 4,800,000,000 were supplied by gas tractors and 300,000,000 by steam tractors. The total number of farm tractors in 1928 reached a total of 768,825[9].

[4] Yearbook of Agriculture, U. S. Department of Agriculture, 1924, table 695, page 1109.

[5] Data from U. S. Department of Agriculture.

[6] Data compiled by Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture.

[7] Kinsman, C. D., " An Appraisal of Power Used on Farms in the United States," Bul. 1348, U. S. Department of Agriculture, 1926.

[8] Harvey Fisk and Sons, "The Tractor Industry and Its Part in Power Farming," 120 Broadway, New York, N.Y.

[9] From data compiled by Farm Implement News, Chicago, Ill.

TABLE II. Tractor and Combine Sales In Three Provinces of Western Canada—Manitoba, Saskatchewan and Alberta[10]

Year	Tractors No.	Combines No.
1924	2,112	
1925	4,053	
1926	6,513	176
1927	10,026	598
1928	17,143	3,657

Mechanical Trends in Agriculture in Other Countries. These trends in agricultural power while quite pronounced in the United States are applicable to certain other countries although the latter perhaps are not so far advanced. Data from three western Canadian provinces show increases in tractor and combine sales as indicated in Table II.

That the use of modern farm equipment in Canada, Argentina, Australia and British South Africa is gaining rapid headway is evidenced by the reports of the U. S. Department of Commerce[11]. Of the $90,747,000 of agricultural implement exports from the United States in 1927 Canada received $30,440,000; Argentina, $16,540,000; Australia, $5,472,00; and British South Africa, $3,138,000, a total of $55,590,000. Or, in other words, these four countries received more than 60 per cent of the total implement exports. Incidentally these countries are the chief competitors of the United States in the world's cereal markets.

Agricultural Engineering Education and Research. The engineering opportunities in American agriculture have developed largely through the educational efforts of the land grant colleges and the U. S. Department of Agriculture. When mechanical power in agriculture came into prominence, through the introduction of the internal-combustion engine, these educational agencies recognized the need of mechanical instruction adapted to agriculture. At first this work was taught as simple mechanics which seems quite natural when one considers the evolution of farm machinery design. The first of these institutions to offer agricultural engineering instruction through an organized department was the University of Nebraska in 1904. Since that time thirty-seven of the forty-eight land grant institutions have departments specializing in some phase of agricultural engineering, and five others have special instructors in this field. The growth of this educational work is shown by Fig. 4.

These agricultural engineering departments have had the responsibility of training students in agriculture in the economics and practical importance of engineering science as applied to the industry. Since the first department was established in 1904, 78,000[12] agricultural college students have received training in some applied agricultural engineering course. The total annual registration in these courses now exceeds 5,000. This type of education, however, is directed toward the utilization of engineering knowledge rather than toward the creative side of engineering development in the industry. For this latter purpose seventeen of the land grant institutions of the United States and some of the Canadian universities offer specialized technical training for the development of professional engineers in this field. Up to January 1, 1926, eight United States colleges and universities and one Canadian university had graduated a total of 268 men. Thirty-seven per cent of these have remained in educational and research work, approximately 15 per cent have become associated with the farm equipment industry, 5½ per cent are in the rural structural field, 7½ per cent in reclamation, 16 per cent are operating or managing farm projects, and the remainder are in activities outside of this field, or are deceased. About 200 students are now enrolled in these technical courses. The men prepared for this technical service are trained fundamentally as engineers, with some basic work in the fundamentals of the agricultural sciences, but their application work and economic training are directed primarily toward the problems of the agricultural industry.

The research work conducted in these land grant colleges and the U. S. Department of Agriculture relating to engineering problems in agriculture is important. During the fiscal year 1926-27, thirty-four land grant colleges and the U. S. Department of Agriculture had a total of 181 men engaged in research work. Some of these were devoting only part time to research, but these were equivalent to 103 (approximately) full time research workers. The type of research carried on by these workers is shown in Table III.

The American Society of Agricultural Engineers. That engineers are recognizing the opportunities in this field is very well shown by the growth of the American Society

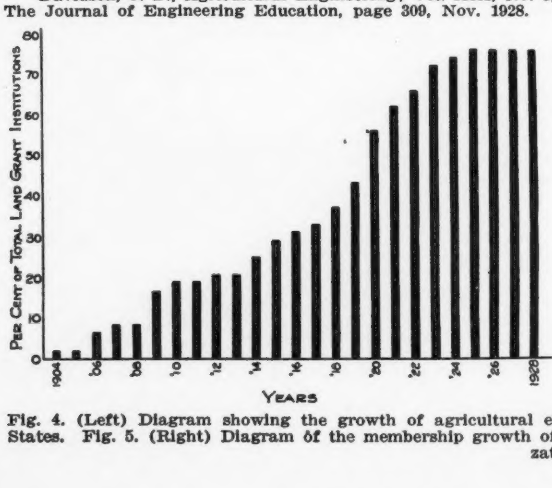
TABLE III. Distribution of Agricultural Engineering Research Workers in the United States as to Type of Studies Conducted in 1926-27[13]

Type of Research	No. of equivalent full time workers employed
Farm Operating Equipment	27
Rural Electrification	18
Buildings, Sanitation and Water Supply	13
Drainage and Land Clearing	19
Irrigation	28
Total	103

The total cost of the research work in these fields for the year reported was $460,311.00.

[10]Vol. 60, No. 1, Farm Implement News, Chicago, Ill. (January 1929).
[11]Commerce Yearbook, 1928, Vol. 1, page 432.
[12]Davidson, J. B., Agricultural Engineering; Vol. XIX, No. 3, The Journal of Engineering Education, page 309, Nov. 1928.

[13]Walker, H. B., Miscellaneous Publication No. 38, U. S. Department of Agriculture, Research in Mechanical Farm Equipment, Dec. 1928.



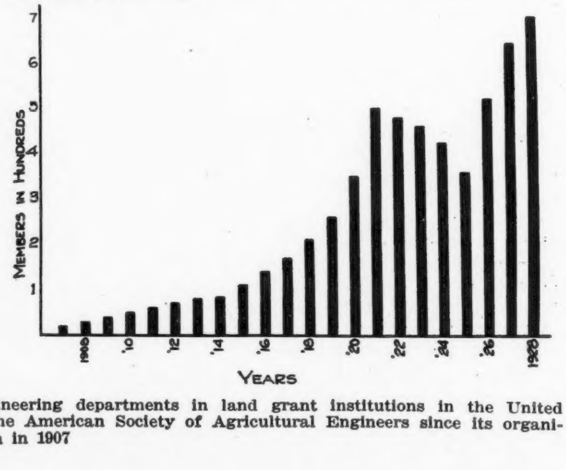


Fig. 4. (Left) Diagram showing the growth of agricultural engineering departments in land grant institutions in the United States. Fig. 5. (Right) Diagram of the membership growth of the American Society of Agricultural Engineers since its organization in 1907

Fig. 6. Midnight plowing scene on an Illinois farm. Mechanical farming permits 24-hour day use of equipment

of Agricultural Engineers. This Society was organized in 1907 at Madison, Wisconsin, by a small group of farm mechanics teachers representing the various agricultural colleges. From that date the society has had a fairly uniform growth, attaining a membership of over 700 in 1928. This growth is graphically shown by Fig. 5[14]. It is interesting to note that thus far its growth shows a very good correlation to the educational developments in the agricultural colleges (Fig. 4).

Agriculture is utilizing far more engineers than those specially trained in the land grant institutions. The membership of the American Society of Agricultural Engineers is made up of engineers trained in civil, electrical, mechanical and chemical engineering, as well as in agricultural engineering. Indirectly, from related industrial fields agriculture enjoys the advantages of engineering assistance from large groups of technically trained men, but as yet there are relatively few who have selected this as a major professional endeavor.

Engineering Fields in the Agricultural Industry. There are three general divisions of the activity for engineers in agriculture: (1) Power and machinery, including rural electrification; (2) farm structures, including water supply and sanitation; and (3) land reclamation. Due to the limitations of this paper all of these fields can not be outlined in detail. The field of power and machinery is attracting unusual engineering attention at present, and in the following paragraphs specific mention will be made of some of the problems and trends in this division of the engineering field. Although less specific mention is made of the other divisions, these should be regarded as having equal potential engineering importance in the industry.

Mechanical Power Development. The references to the power developments in agriculture, which have heretofore been mentioned are indicative of the importance of mechanical equipment to modern agriculture. So long as animal power was in the ascendency engineers found little to attract them in the design of primary power units for agriculture. The scientific production of animal power is based on the biological sciences. The production and processing of fuels (feeds) for animal motors is also largely a biological problem. For these reasons engineers found little of interest in agriculture until mechanical power met with general acceptance by farmers. This condition in the industry has been a deterrent to the engineering development of agricultural power. The farmer who produced both his power plant and fuel was naturally slow to accept a mechanical substitute requiring some degree of mechanical skill for satisfactory operation and which consumed mineral fuels rather than farm products. Although the internal-combustion engine has contributed to the industrial revolution now taking place in agriculture, it is significant that nearly half a century elapsed from the time it was first invented until it became an important economic factor in farming.

The early applications of mechanical power were for stationary operations, but the bulk of farm work has always been done by a mobile power plant. The first endeavors of manufacturers to apply the internal-combustion engine to drawbar work on the farm resulted in heavy, awkward units having exposed gears and poor lubrication systems. These were not satisfactory or of wide application principally because the thought of these pioneer designers apparently was centered about the actual substitution of the tractor for animal power. The efforts to make a horse out of the tractor were practically fruitless for all operations except plowing. Fortunately plowing represents one of the greatest energy consuming operations in agriculture and this outlet for the tractor lent encouragement both to the designer and to the manufacturer.

The rapid development of the automotive industry has had a favorable effect upon the development of the gas tractor. The use of enclosed gears, high-pressure oiling systems, air cleaners and oil filters developed largely through automotive applications have been successfully applied to farm tractors. These have been great factors in the production of a highly dependable power unit for field operations under the extremely severe conditions common to agricultural work. A test[15] completed in September 1928 by the agricultural engineering division of the University of California establishing a world's record for a non-stop tractor run is indicative of the dependable performance of modern gas tractors. This tractor, one of the crawler types, was operated continuously for 408 hours at actual field work drawing a disk and float over land from which a crop of sugar beets had been harvested. During the test the tractor traveled 1,329.97 miles covering an equivalent area of 1,290 acres. At the close of the test before any adjustments had been made on the engine, a maximum drawbar test was run producing 21.09 maximum horsepower or more than the manufacturer's rating.

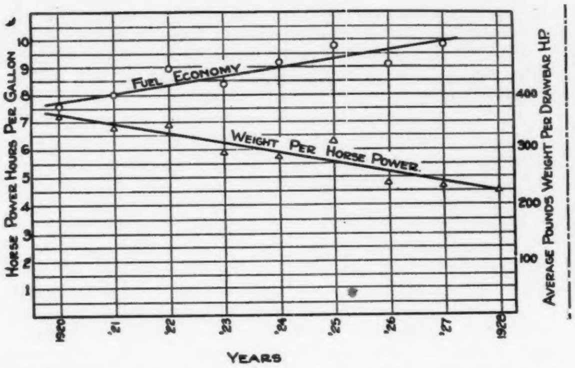
New Opportunities in Farm Equipment Design. The mechanical excellence of farm tractors attained through careful development and engineering, has stimulated the confidence of the farm operator, and at the same time it has created a new attitude toward the application of mechanical power to agricultural production. Animal power reached certain limitations in application. Operating units exceeding eight horses have never come into general use. The space required for animal travel has fixed row spacings for certain crops and the irregular but somewhat fixed speed of animals developed certain limitations in farm machine design. With mechanical power the designer has control over these limiting factors thus permitting design for a wide range of operating conditions. Row spacings may be changed; speeds may be varied; accurate timing of machine parts is possible; automatic operation becomes possible, and 24-hour-day operation feasible (Fig. 6). These factors are just now gaining recognition, and they afford attractive possibilities in farm machinery design and farm management which will add momentum to the mechanization of agricultural operations.

Trends in Tractor Design. The changes taking place in tractor design in America are shown very definitely as to trends by the Nebraska tests. These tests which are required by law in the state of Nebraska are accepted by the tractor industry as a standard testing method. Fig. 7[16] indicates graphically the trend in fuel economy

[14]Data from Raymond Olney, Secretary, American Society of Agricultural Engineers, St. Joseph, Mich.

[15]Stirniman, E. J., and Hoffman, A. H., "A Field Test of Tractor Wear and Endurance." Vol. 10, No. 1, Agricultural Engineering, page 35, Jan. 1929.

[16]Wallace, H. L., "Recent Changes in Tractors as Noted from the Nebraska Tractor Tests," Vol. 9, No. 3, Agricultural Engineering, page 91, March 1928.



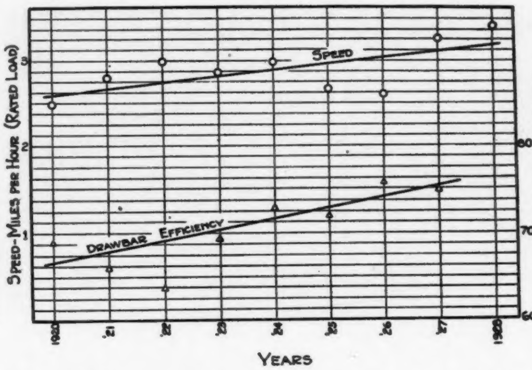


Fig. 7. (Left) Trends in fuel economy and weight per horse-power of American-made tractors as shown by the Nebraska tests. Fig. 8. (Right) Trends in speed and drawbar efficiency of American-made tractors as shown by the Nebraska tests

and weight per horsepower as shown by these tests from 1920 to 1927. Greater fuel economy with less weight per horsepower is the trend in recent designs. How far this will continue will depend somewhat upon the types of fuel utilized. Immediate tendencies in design in the United States are toward the greater use of gasoline, and, if this continues, the trends in weight per horsepower as indicated in Fig. 7 may continue. In some European countries the Diesel type tractor engine is being developed with considerable promise, and an expansion in this development may be expected. The use of the power take-off from tractors for the operation of field implements is a development which has contributed to the more flexible application of mobile power units for agriculture.

Fig. 8[16] shows graphically the developments in speeds and the drawbar efficiencies. While these tests indicate a trend toward higher speeds it would seem apparent that future designs will take care of rather wide ranges in speeds made necessary by the various field operations incident to crops. Efficiency may or may not be attained by rate of travel. More careful analysis of farm operations are needed to determine efficient travel rates for farm tractors. Fig. 8 also shows an upward trend in drawbar efficiencies. This is a very encouraging trend.

Some Results of the Mechanization of Farming. The practical adaptation of the tractor to new field uses is a development of the past decade. The cultivation of row crops until recent years has been most economically performed by horse-drawn equipment. The cultivating type of tractor is now a reality and it is coming into extensive use in certain sections of the cotton belt and throughout the great corn belt of the United States (Fig. 9).

In the older cotton belts of the Nation from 60 to 75 hours of man labor are required to produce an acre of cotton up to time of harvest. This excessive labor requirement is due to the use of one horse (mule) machinery and hand methods for chopping, hoeing and other cultivation work. On tractor-operated farms in West Texas, where the cultivator type of tractor is used for all cultural work, the labor requirements per acre, for cotton up to picking time, have averaged 10 man-hours[17] per acre. With mechanical power one man has been able to care for 200 acres of cotton up to harvest time as compared to 15 to 20 acres per man in the older regions.

The preharvest labor costs under such varying conditions show a wide range per pound of lint cotton produced. Under certain conditions where mechanical farming is practiced these may be as low as 0.06 man-hour per pound, while in the older cotton belts with much hand work the preharvest cost of lint cotton is about 0.45 man-hour per pound. The total man labor requirements which include harvesting, for producing a pound of lint cotton in the above districts range from about 0.7 hours of man labor for the eastern states to about 0 2 man-hours in the western cotton district of Texas.

There is a similar differential in the man labor requirements in corn production between the corn-producing sections of the old South and the great corn belt of the northern central states. In the former where small equipment prevails about 2.5 hours[18] of labor are required for producing a bushel of corn and caring for the stover, while in the latter area with larger equipment about 0.5 hours of labor are necessary when the ears are husked by hand. Recent developments with larger mechanical equipment, including harvesters, indicate that corn may be produced with as little as 0.10 man-hours of labor per bushel. In wheat production the requirements range from 2.5 hours of labor per bushel for the southern states to about 0.3 hours in the Pacific Northwest.

Harvesting Machinery. Engineering progress in harvesting machinery has been noteworthy during the twentieth century. The small grain harvesting methods have changed most. The combine method of cutting and threshing grains at one operation is now used extensively in the spring and winter wheat belts of North America. With modern machinery one man today can harvest as much small grain as thirty or more men could a century ago. The man labor in wheat harvest where combine methods are used has been reduced to approximately ¾ hour of man labor per acre (Fig. 10). Corn harvesting machinery has been slower in development but rapid strides are now apparent (Fig. 11).

Cotton harvesting consumes from 30 to 50 per cent of the total man-hours required for production. The development of a harvester for this crop is the control in the mechanization of cotton production. The research work conducted by the state and federal experiment stations[19] and the field development work conducted by implement companies have greatly accelerated progress in cotton harvesting during the past three years. Further encouragement has come from improvements in ginning machinery. The developments have been along two general lines: First, by simple methods of stripping the cotton bolls from the plant and later removing the burrs from the seed cotton previous to ginning, and, secondly, by mechanically picking the seed cotton from the burrs in the field. The former method has many drawbacks particularly in the older cotton producing sections. It is, however, a simple method which has been economically employed in the western cotton belt of Texas. The mechanical pickers are practically all of the spindle type. As yet these are rather

[17]Gabbard, L. P., and Jones, F. R., "Large Scale Cotton Production in Texas," Bul. No. 362, Texas Agricultural Experiment Station, July 1927.

[18]Brodell, A. P., "Labor Requirements Measured for Principal Crops," Yearbook of Agriculture, U. S. Department of Agriculture, 1926, page 466.

[19]Jones, D. L., Hurst, W. M., and Scoates, D., "Mechanical Harvesting of Cotton in Northwest Texas," Circular 52, Texas Agricultural Experiment Station, Nov. 1928.

complex machines but there is much encouragement in the results obtained thus far from their use. Results already obtained in harvesting cotton mechanically have shown that such harvesting is possible without lowering the quality of the product. With all phases of cotton production mechanized it should be possible to produce this farm commodity at much lower costs than now prevail.

Tangible Objectives, a Need for Engineering Application. The agricultural engineer working in conjunction with the mechanical engineer has many obstacles to overcome in applying engineering science to agricultural production. The labor saving appeals while not yet exhausted can not always remain the principal stimuli in engineering design. It is true immediate efforts will be directed toward labor-saving machinery particularly for such crops as tobacco, cotton, sugar beets, potatoes, fruits and truck crops, but in the future the engineer must concern himself more directly with the biological relationships in engineering design. Between 25 and 30 per cent of all agricultural power when measured in horsepower-hours is utilized in the various tillage operations. To conduct this huge task efficiently involves the effective use of power. One part of the problem is to supply a suitable power plant and the second is to effectively apply this power to crop production. The relation of output to input is the measure of efficiency. Most tillage practices are for the purpose of developing a soil condition known as tilth which is, after all, a soil environment for the promotion of vegetable life and development. One of the most troublesome problems facing the agricultural engineer is to find a measure of this factor or condition called tilth. When this can be measured even roughly the engineer in designing field tillage equipment will have a tangible objective.

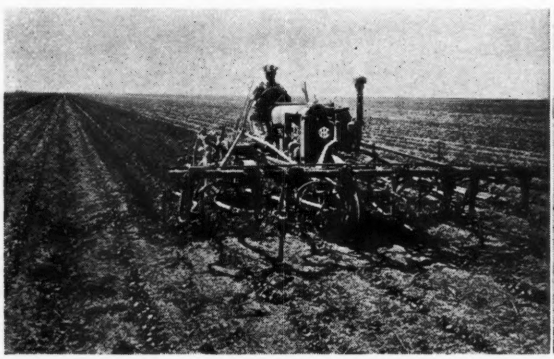
There is some evidence tending to show that the empirical standards developed by agricultural practices for tillage may be without scientific foundation. The cost of cultivating peach orchards in Stanislaus County, California[30], declined from $21.95 per acre in 1925 to $10.36 per acre in 1928. These decreases in costs were obtained almost entirely by decreases in the amount of tillage practiced and were accompanied with some increase in production. These data are submitted merely as evidence of a new trend of thought in agriculture. When power was low in cost and relatively plentiful, as in the human and animal power epochs of agriculture, little analytical thought was given to such factors, but with the advent of the mechanical epoch in agricultural power these factors attain significance.. To be able to measure tilth in biological terms which can be translated into engineering units, or vice versa, is a problem for scientific study requiring the combined skill of both agricultural and engineering scientists.

[30]Data compiled by Extension Service, University of California, Berkeley, Calif.

Engineering the Plow. The plow is a marvelous tillage implement. Its use became universal through the application of animal energy. Animal power which is essentially linear power is most efficiently utilized by dragging field implements. Mechanical power, on the other hand, may be converted into rotary power just as easily as linear power. In the process of tillage it is important to transform the energy input into soil manipulations which will result in promoting optimum tilth. With mechanical power it is no longer necessary to depend entirely upon the linear applications. This has caused engineers to think of new ways of utilizing energy for tillage purposes. Processes which will not only turn or stir the soil but which will pulverize, mix and pack the seedbed area in one operation seem to offer promise for new efficiencies. The rotary plows have been developed with this objective. Such, however, have not as yet been able to utilize efficiently the energy input. The tiller plow which is a combination of the modified moldboard plow with an attached rotary pulverizer is a new development in tillage implements. This implement is mentioned because it is a product of engineering thought as applied to agriculture, and it has been developed in an effort to secure the efficient application of energy to soil tillage. The vertical disk plow now widely used in the Great Plains area is another example of an attempt to break away from traditional tillage practice (Fig. 12).

Electricity in Agriculture. The use of electricity as an agricultural power has gained considerable prominence in North America during the past decade. This type of energy, because of its flexibility and adaptation to household and farm chore work, is destined to become an important factor in agricultural power. The efforts in the United States to develop new data through organized studies are especially noteworthy. More than twenty of the states have formed committees on the relation of electricity to agriculture which have for the most part cooperated with the agricultural and engineering experiment stations of the land grant institutions in making detailed studies of the application of electrical power to farm work. The results of these efforts are reflected in the increased number of farms receiving such service. Table IV gives the number of farms served by central station plants in 27 states as determined by the Rural Service Committee of the National Electric Light Association for the years indicated.

Agricultural Engineers Needed in Rural Electrification. In the development of this service the utility companies have recognized the need of agricultural knowledge. This is indicated by the following quotation taken from the report of the Rural Service Committee of the National Electric Light Association for 1925:



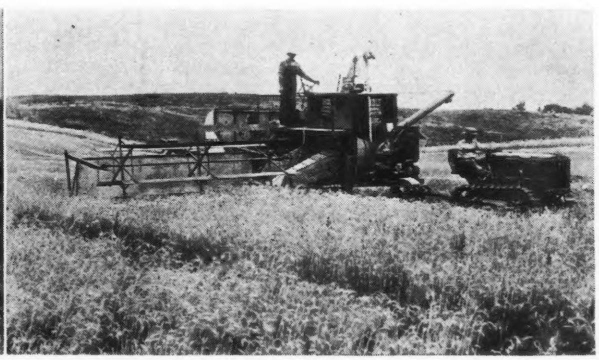


Fig. 9. (Left) Mechanical power is causing a revolution in agricultural methods. With this type of equipment cotton is produced up to harvest time with 10 man-hours of labor per acre. Fig. 10. (Right) The "combine" method of harvesting grain requires the expenditure of ¾ man-hour per acre. The two men with the equipment shown can do as much harvest work as 60 or more men could do a century ago

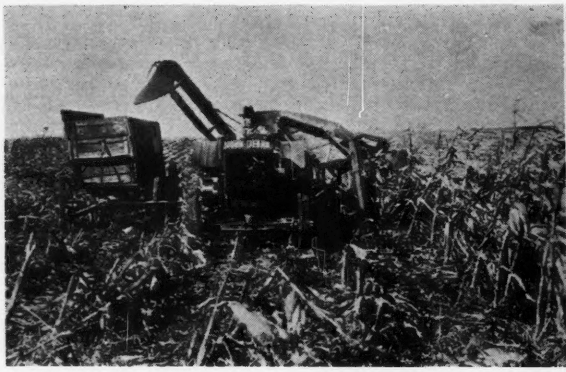


Fig. 11. (Left) Mechanical corn pickers are successful with tractor power. Fig. 12. (Right) The vertical disk plow, an implement making use of new principles in tillage practice

"The rendering of rural electric service involves problems of both an electrical and an agricultural character. The electrical development presents no problems which will not yield to systematic study by talent already employed by the electric light and power industry. The agricultural industry is entirely unfamiliar. For this reason we believe that a utility entering upon a rural electric service development program should secure the services of a man trained along agricultural lines and with an agricultural viewpoint. Such a man should be sympathetic towards agriculture and able to talk the farmer's language. This is particularly necessary since the development of rural service upon a sound basis depends so largely upon the proper development of an agricultural load and requires the services and experience of one familiar with agricultural problems. We, therefore, recommend the employment of such a man by utilities of sufficient size to warrant it, and, in the case of small utilities, we recommend the development of one in its existing organization to the greatest degree possible along agricultural lines and the assignment to him of all problems involved with rural service."

The utilities of the United States responded to this policy by organizing rural service departments. In 1925 nineteen companies reported such organizations. The following year 57 companies had organized departments, and 43 companies reported special personnel for this work. In 1927, 160 companies were prepared with special engineering service for agricultural consumers with a total personnel of 403 men specially trained in rural electrical work.

Rural Electrical Investigations. This progress has been possible through the cooperation of the national Committee on the Relation of Electricity to Agriculture, the various state committees, and the experiment stations. In 1926-27 more than $60,000[21] in private funds were available for investigational work. Eighteen experiment station workers devoted full time to research studies in this field. The many practical methods found for farm duties such as pumping water, cutting ensilage, milking cows, grinding feed, cooking, sweeping, refrigeration and laundry have already demonstrated the practicability of rural service, both as a profitable development for utilities and as a profitable source of energy for agriculture. New applications are being studied for such work as heating hot beds, precooling fruit, dehydrating farm products, controlling insect pests and stimulating plant growth.

TABLE IV.
Number of Farms in 27 States Receiving Electric Service from Central Station Plants

Year	No. of farms served
1923	121,854
1926	227,442
1928	339,456

Rural Structures. The task of the engineer interested in the structural problems of the agricultural industry is difficult, not because of the technical problems involved, but due to the state of flux found at present in the industry. The mechanical developments of the past decade have brought about new visions in methods of production and processing of agricultural products. Moreover, the public regulations for quality in production are becoming increasingly more rigid. The materials of construction are varied, with labor costs for erection mounting. Management data on the care of animals and the storage of crops are lacking in specific details needed for engineering analysis. For these reasons the agricultural engineer in the structural field finds it difficult to apply his technical knowledge with complete confidence as to its economic soundness. In this, as in other agricultural engineering work, the great immediate need is to develop research which will provide the engineer with the necessary technical background for economic designs.

The engineering appeal in farm structures is such that few engineers are attracted to this field. The fact that farm buildings for the most part are fabricated on the farm without engineering or architectural assistance has been a deterrent to the development of structural design. This work thus far has been supported principally by public agencies such as agricultural colleges, but in recent years the engineering staffs of the various building building material associations have contributed helpful data.

Regardless of the lack of the spectacular in this field, there are many engineering problems to be met. For example, in the state of Iowa[22] (U.S.A.) the farmers produce annually about 250,000,000 bushels of corn, eighty per cent of which is used on the farms for feeding livestock. The storage of this corn alone requires tremendous investments in structures. Furthermore, the animals consuming this corn must be housed in properly planned sanitary structures to meet the requirements of economic management. A rapid expansion of engineering interest in the farm structures field is imminent.

Land Reclamation. The land reclamation field has always been attractive to engineers. In fact the reclamation engineer is the forerunner of agricultural development in reclaimed areas. The many fine engineering structures on reclamation projects throughout the civilized world stand as monuments to the engineering skill and personal courage of the engineer. These efforts have brought to-

[21]Walker, H. B., "Research in Mechanical Farm Equipment," Miscellaneous Publication No. 38, United States Department of Agriculture, Dec. 1928.

[22]Giese, Henry, "The Development of Research in Farm Structures," paper presented at Structures Division meeting, American Society of Agricultural Engineers, Chicago, Ill., Dec. 1928.

gether the work of the civil, electrical and mechanical engineers. Are engineers to be satisfied with the material contributions to reclamation, great as they are; or should engineers extend their method of thinking into the ultimate objectives of reclamation works? The conservation and utilization of great material resources such as soils and water involve many engineering problems. The agricultural engineer is concerned primarily with these things. The economic use of water in irrigation; the control of water through drainage; the conservation of soils by the control of soil erosion, and the clearing of lands of obstacles such as stumps, trees, debris, or even refractory soil layers, all attract the engineer in agriculture. Here again, as in other engineering problems in the industry of agriculture, the engineer encounters the need of scientific assistance which must be supplied by workers in related biological fields.

The potentialities of agricultural reclamation are large and varied. These include the reclamation of new areas by drainage, irrigation, dry farming, and land clearing. In the United States alone, the potential area which may respond to these various forms of reclamation total an area equal to at least 50 per cent of the present improved farm lands of the Nation. Similar conditions prevail in many other parts of the world. Economic necessity of course must be the principal urge for the development of such lands, but the application of engineering science to these problems when combined with the contribution from related scientific fields in agriculture afford methods of attack which a few years ago were considered beyond the realm of probability.

An Engineering Obligation. The engineers of the world should look with confidence to the development of this great potential engineering field—engineering in agriculture. It is not only endowed with interesting engineering problems, but it affords the engineering profession an opportunity to render a great service to mankind. Engineering and poverty do not go hand in hand. Those who employ engineering wisely are privileged to enjoy the greatest comforts and luxuries of life. Agriculture is a basic industry. It is responsive to engineering science. This science if wisely applied to agricultural production, processing and distribution can do much to wipe out the spectre of famines, and likewise bring to the rural peoples of the world many comforts in living now denied our agricultural workers.

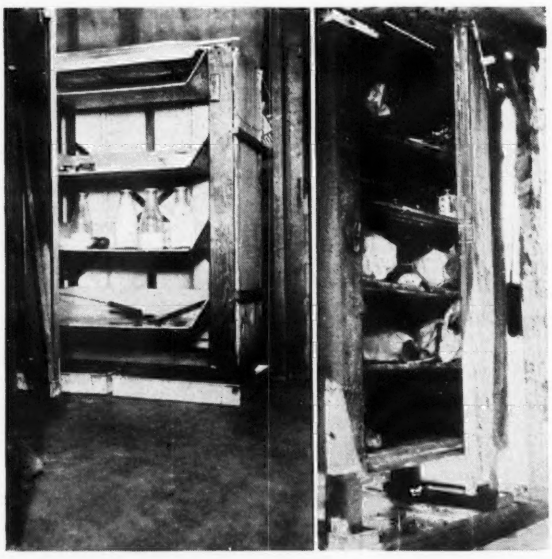
Performance Tests on Evaporation Type Coolers

By W. L. Ruden[1]

"HOW cold does it get?" is a question that is frequently asked regarding the evaporation type cooler. As far as I could learn, no tests had been conducted to determine how much cooling effect one could expect under different conditions. Therefore, two coolers that were in operation in Davis (Calif.) homes were tested to find out what cooling effect one could expect in that locality and also what caused performance to vary and to what extent.

The term performance, which was selected as a basis of comparison, may be overworked, but it applies in this case about as well as any other. It is on a percentage basis and is found by dividing the difference between temperature of cooler and air by the difference between the wet and dry bulbs of a sling psychrometer, and multiplying the quotient by 100.

[1]Assistant in farm mechanics, division of agricultural engineering, University of California. Jun. Mem. A.S.A.E.



(Left) The metal evaporation type cooler used in the California tests. (Right) The wood cooler used in the tests

One hundred per cent performance would imply that the cooler temperature was as low as the wet bulb, while 50 per cent performance would signify that it was half way between the air temperature and that of the wet bulb. Actually this is not quite true due to a variation in the air temperature and the readings of the dry bulb.

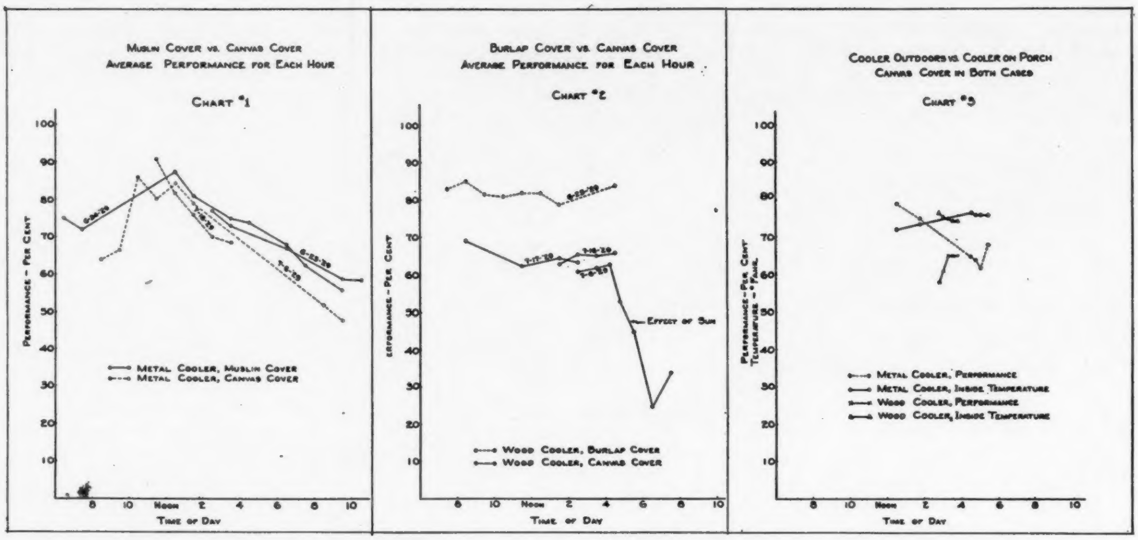
The two coolers that were tested are herein designated as the metal and the wood cooler. They differed considerably in construction, one having a framework of metal and the other of wood. Their details, the method of testing, and other information may be secured from the complete report available through the Agricultural Engineering Division, University of California, at Davis, California.

The metal cooler was located on a screened porch with all except about 15 square feet of the wall space either boarded up or covered with canvas. The wood cooler stood in the open with only a wood shelter overhead so that there was a free circulation about it. However, the shelter was not large enough to shade the walls of the cooler for about an hour in the forenoon and late in the afternoon, even with the help of the house and some trees. This condition was controlled with a special curtain during the tests.

The metal cooler was covered with muslin for one series of tests and with 10-ounce canvas for the second series. The wood cooler was tested with burlap and canvas covers.

The above suggests that there was an opportunity for the following comparative studies:

1. Cooler on porch vs. cooler in open.
2. Muslin cover vs. canvas cover.
3. Burlap cover vs. canvas cover.
4. Cooler in shade vs. cooler exposed to sun.
5. Observation of details of construction.



These charts represent graphically the results of the California tests on the evaporation type cooler

The following is a resume of the results of these tests:

1. Chart No. 3 shows that the cooler on the enclosed porch gave a slightly higher performance than the wood cooler which was unprotected. But that does not mean that the temperature in one cooler was lower than in the other. Actually there was practically no difference in the inside temperatures as shown on the same chart. The higher performance was offset by the relative humidity which was about eight per cent higher on the porch on that day.

2. The muslin cover gave a higher performance than the canvas cover, as shown on Chart No. 1, but the difference is not great enough to give it a decided advantage. In fact, the muslin was not as satisfactory as the canvas because it dried out much more readily. Whenever dry spots develop in the cover, that lowers the performance appreciably.

3. Burlap, which probably is used for a covering material more than any other goods, proved its superiority over canvas as shown by Chart No. 2. But other factors mentioned in the conclusions must be considered.

4. Chart No. 2 also shows what happened when the sun shone on the rear wall of the cooler late in the afternoon. The performance dropped quite rapidly from about 60 per cent to an average of 25 per cent for one of the hour intervals. In other words, the temperature of the cooler went almost as high as that of the surrounding air.

5. The U. S. Department of Agriculture describes the construction of evaporation type coolers in their Information Series No. 41, entitled "The Iceless Refrigerator," and on pages 8 to 12 of Farmer's Bulletin No. 927.

In relation to construction, the following points are worth noting:

1. The wood cooler under test had a tightly boarded top covered with building paper. A petcock, connected to the city water, was installed overhead to give a constant drip. A burlap sack was spread over the top of the cooler to distribute the water to the four sides.

2. The metal cooler had a metal pan on top which was kept full by a continuous drip from a petcock. Cloth wicks drew the water over the edge of the pan. In both of the above systems the top of the cooler had to be fairly level.

CONCLUSIONS

The location of the cooler has some bearing upon its operation. For instance, if it were in a tightly closed room, the evaporation would raise the relative humidity to such an extent that the cooling effect within the cooler would be decreased.

The other extreme regarding location is that of the wood cooler. The tests were made when it was comparatively calm or there was a south breeze. At Davis the hot winds come from the north. Therefore, under the most severe conditions of hot winds, the performance of the wood cooler would probably be much lower. This is an opinion based upon observation and not on test data.

Canvas is superior to muslin as a covering material because it does not dry out so readily and is more durable. These points overcome the slightly higher performance.

Although burlap ranks about twenty per cent higher in performance than canvas, it is not that much superior. It dries out easier, is not so durable, and may be faulted from a sanitary viewpoint. I prefer to use canvas.

Any evaporation type cooler should be well shaded at all times. Even filtered sunlight as it comes through trees lowers its performance to a marked extent.

The construction of a cooler has an indirect bearing upon its performance. If the method of wetting the cover is not satisfactory, that will reflect in a lowered performance. Both of the methods used on the coolers tested proved satisfactory.

The type of construction also has an important bearing upon the ease of operation. A continuous water supply as from a dripping petcock is a valuable feature. Automatic control of the waste is also a time saver.

Another valuable detail is to have the cooler legs standing in pans of water to keep out the ants.

If properly constructed, the evaporation type cooler will give satisfactory results in all except the humid regions. However, it is not equal to a refrigerator, except in very dry regions in reasonably high altitudes where the air temperature does not get very high. Rather it should serve as a supplement to a refrigerator in taking care of vegetables and similar foods to which it is peculiarly adapted. But where ice or mechanical refrigeration is out of the question, an evaporation type cooler will serve as a fair substitute.

The Rational Method of Estimating Run-off from Small Agricultural Areas[1]

IN THE beginning engineers estimated the required sizes for drains and channels from observations of the discharge in channels seen flowing from known watersheds during storms, and from the sizes of adequate watercourses with which they were familiar. Later attention was given to the precipitation, the run-off being estimated from the depth of rainfall over the watershed area. It was then discovered that the rate of run-off per unit of watershed area was greater for small than for large watersheds and that differences in intensities as well as amounts of rainfall should be considered in estimating the run-off from a watershed. A great many empirical formulas have been developed from time to time to take care of the various factors that were found to influence run-off. They were generally developed for particular watersheds or for certain localities and have not been found to be very satisfactory for general application. In late years these formulas are being gradually abandoned by engineers in charge of storm sewer design and are being superseded by what is generally known as the "Rational Method" of estimating storm water run-off. While this method has been in use for some time in storm sewer design where quite accurate estimates of storm water flow are essential, it has never been employed to any great extent in estimating run-off from agricultural areas in the design of such works as culverts, soil-saving dams, terrace systems and drainage channels. A need for a more accurate method of estimating run-off from small agricultural areas is quite generally recognized by engineers charged with the design of such works, which will enable them to plan both adequate and more economical improvements.

The Rational Method. The rational method is based on the theory that the maximum rate of run-off from a watershed occurs when rainfall from every portion of the watershed is contributing to the flow at the outlet. In order that the most remote point (measured in time) is contributing to the flow at the outlet, it is necessary that the rain continues as long as it takes for the water to travel from the most remote point to the outlet. The time required for the water to travel this distance is called the time of concentration for the watershed. The maximum rate of run-off would therefore occur for a rain of maximum uniform intensity over the entire watershed that continues as long as the time of concentration for the watershed.

[1]1928-29 report of the Committee on Run-Off from Agricultural Lands—C. E. Ramser (chairman), R. A. Norton and W. D. Ellison—presented at the 23rd annual meeting of the American Society of Agricultural Engineers, at Dallas, Tex., June 1929.

The rational method is expressed by the formula, $Q=CIA$, where Q is the rate of run-off in cubic feet per second from a given drainage area; C is a coefficient representing the ratio of the maximum rate of run-off to the maximum rate of rainfall for the period equal to the time of concentration; I is the maximum rate of rainfall in cubic feet per second per acre of watershed, or approximately in inches per hour; and A is the drainage area in acres. Although this formula or expression appears to be very simple, the three factors take into consideration practically all conditions that influence run-off.

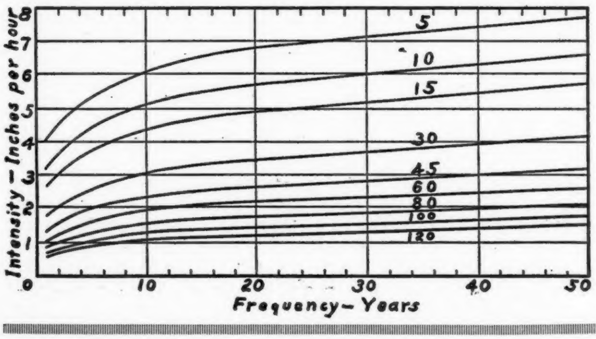
The Coefficient "C". The value of the coefficient C depends primarily upon the nature of the soil, surface slopes, and surface cover of the watershed. It also varies largely with the intensity of the rain and the degree of saturation of the watershed at the beginning of the period taken as the time of concentration. All of these conditions govern the amount of water that percolates into the soil which does not contribute to the peak run-off. Surface storage also influences the value of the coefficient C. The effect of evaporation is practically negligible for peak discharges from small watersheds for which the time of concentration is comparatively short. It is practically impossible to evaluate accurately the effect of these various conditions on the value of C so that it is generally necessary to rely upon values of C that have been determined for watersheds by actual measurements of the rainfall and run-off. Values of C determined in this manner represent the composite effect of all conditions influencing C.

The Factor "I". The value of the factor I in the formula depends upon the intensity of the rainfall for different periods of time, the shorter the period of time the greater the intensity. The period of time to be used for any particular watershed is equal to the time of concentration for the watershed.

Time of Concentration. The time of concentration is influenced by a great many factors, some of which are the shape, slopes and cover of the watershed; the fall, contour and condition of watercourses; surface storage; and the degree of saturation of the watershed at the beginning of the time taken as the time of concentration.

Shape. The time of travel of the water from the most remote point to the outlet of a watershed depends to some extent upon the shape of the watershed. A long narrow watershed would have a longer time of concentration than a fan-shaped watershed with similar drainage area.

Slopes of Watershed. Rain water runs off of steep slopes faster than off of flat ones, and the faster the water runs off of the slopes, the shorter will be the time of concentration.



Curves showing relation between frequency and intensity of rainfall for storms of various duration. Figures on each curve denote minutes of duration

Cover of Watershed. Vegetation on a watershed tends to reduce the velocity of the run-off water and thus prolongs the time of concentration.

Fall of Watercourses. The rate of travel of the water in the watercourses depends largely upon the fall so that the greater the fall the less is the time of concentration.

Contour of Watercourses. Comparatively straight watercourses require less time for water to travel along their courses than winding channels and so have a corresponding effect upon the time of concentration.

Condition of Watercourses. The velocity in clean watercourses is considerably less than in channels clogged up with vegetation, and the time of concentration varies inversely as the velocity.

Surface Storage. Surface storage by holding back the water until depressions on the surface of the watershed are filled increases the time of concentration.

Soil Saturation. Like surface storage, water that is stored in the soil at the beginning of the period taken as the time of concentration serves to prolong the time of concentration. If the soil is saturated from previous rains there will be practically no water stored.

RAINFALL

Under the subject of rainfall a study should be made of rainfall intensities, their frequencies and distribution.

Intensity. The intensity of rainfall for short periods has been found to vary inversely with the duration of the rain. Extensive rainfall measurements with self-recording gages have been made throughout the United States by the U. S. Weather Bureau and other agencies. These measurements afford ample data for the construction of curves from which can be determined the probable rainfall intensity for different frequencies for any period of time. The period of time that should be used for any particular watershed is equal to the time of concentration for the watershed.

Frequency. Records of intense rains have been kept for a considerable number of years from which the probable frequency of different rainfall intensities for certain periods can be determined. The accuracy with which the probable frequency of rainfall intensities can be predicted will continue to increase as the length of the rainfall records grow.

Distribution. It has been found by rainfall measurements that the intensity of rainfall is greater over small areas than over large areas. For comparatively large areas it is rather important that the distribution of rainfall be given consideration while for small areas of less than one square mile it is not so important and in most instances can be neglected. Data on the distribution of rainfall are extremely meager. Several of the larger cities are collecting data on this subject for use in storm sewer design. No doubt a growing attention will be given to this subject as the available experimental data increases.

DETERMINATION OF FACTORS IN FORMULA ($Q=CIA$)

Coefficient "C". The accuracy with which C can be estimated for a particular watershed depends upon the availability of experimental data on values of C for watersheds with similar characteristics. As the field of experimentation grows, eventually, values of C for practically all varieties of watersheds will have been determined and the problem of selecting the proper value of C for any particular watershed will be greatly simplified. The method of procedure will then be somewhat analagous to the method employed in choosing the proper value of N in Kutter's formula for computing the capacity of an existing channel which consists of referring to channels, in similar conditions and with similar hydraulic elements, for which the value of N has been determined.

Until the time of adequate experimental data arrives, it will be necessary in many instances to select the value of C by making necessary allowances for differences in the characteristics of the watershed in question and those of watersheds for which the value of C has been determined. This will require good judgment and a careful study of the comparable characteristics of the watersheds.

The Factor "I". The factor I is determined from a knowledge of the rainfall intensity corresponding to the time of concentration for the watershed.

Time of Concentration. The time of concentration can in some instances be estimated from the time of concentration obtained by experiment on other watersheds, due allowance being made for differences in all conditions affecting this time, which have been previously discussed. If comparisons with other watersheds cannot be made, the time of concentration can be determined approximately by estimating the time required for water to travel from the most remote point to the outlet of the watershed. The time required for the water to travel from the remote point to the nearest watercourse can be determined by first estimating the velocity from a knowledge of the fall, condition of the surface and possibly storage conditions. To determine the time required for water to flow through the watercourse to the outlet, the velocity can be computed by the Kutter and Chezy formulas, the fall, cross-sectional area, hydraulic radius and condition of channel being known. With the velocity and distance known the time of travel can be computed. In order to determine approximately the size of channel required, where channel improvements are contemplated on a watershed, so that the velocity can be computed, an empirical formula can be employed to advantage.

Rainfall Intensity. Having determined the time of concentration for the watershed, the next step is to ascertain the probable rainfall intensity for this time of concentration to be provided for in the proposed improvement. For most improvements it would be impracticable and uneconomical to make provision for the greatest rainfall intensity ever recorded. A decision must be made as to the frequency that it is permissible that the improvement be overtaxed—that is, whether it should provide for such rates of rainfall as occur once in one, ten, twenty-five, or more years. In reaching this decision due consideration should be given to all interests involved.

From the foregoing it is obvious that in the design of improvements for small watersheds it is not only important that the probable rates of precipitation be known but also the probable frequency of the occurrence of these rates.

GENERAL DISCUSSION AND APPLICATION OF RATIONAL METHOD

The limited length of this report does not permit the inclusion of the results of experiments made by the U. S. Department of Agriculture on a number of small agricultural areas in West Tennessee and Southeast Missouri. A table giving the results of the measurements of rainfall and run-off on one of these watersheds accompanies this report to illustrate the method employed in tabulating the results and for use in illustrating the application of the data to a practical problem. Also a figure of curves accompanies this report showing the relation between frequency and intensity of rainfall for storms of various duration. These curves are applicable to a certain section of the United States which includes the watershed in Tennessee for which data in the accompanying table is given. They were plotted from precipitation data in Table 15 of Meyer's "Elements of Hydrology," which data were compiled from the U. S. Weather Bureau records taken at the following 19 stations for the period 1896 to 1914: Boston, Albany, Pittsburg, Elkins, Asheville, Knoxville, Memphis, Cairo, Indianapolis, Cincinnati, Cleveland, Detroit, Grand Haven, Chicago, Madison, St. Paul, Moorhead, Yankton, Dodge City. These stations showed similar rates of precipitation and were grouped together for the purpose of indicating the probable frequency of rains during a period of time longer than the periods for which the records were available at each individual station.

From these curves the engineer can readily determine what rate of rainfall intensity should be adopted as the basis of his improvement, having first decided with what

TABLE I. MEASUREMENTS OF RAINFALL AND RUN-OFF FOR WATERSHED NO. 1 ON MURCHISON FARM, NEAR JACKSON, TENNESSEE

Drainage area, 20.7 acres Time of concentration, 5 minutes

Date of rain 1918	Rainfall during time of concentration	Average rate of rainfall during time of concentration	Maximum Rate of Run-Off		Coefficient of run-off (Ratio of maximum rate of run-off to average rate of rainfall)	Rainfall prior to period taken as time of concentration	Previous Rains over 0.08 inch	
							Date	Amount
	Inch	Inches per hr.	Second-feet	Inches per hr.		Inches		Inches
Feb. 19	0.20	2.40	20.0	0.96	0.40	0.39	Feb. 15 Feb. 12 Feb. 6	0.10 0.41 0.20
Apr. 16	0.32	3.84	26.5	1.27	0.33	1.21	Mar. 23 Mar. 20 Apr. 20	0.23 0.13 0.82
Apr. 28	0.37	4.44	38.0	1.82	0.41	0.09	Apr. 19 Apr. 17 Apr. 16	1.59 0.72 1.55
May 7	0.30	3.60	28.5	1.37	0.38	0.18	Apr. 28 Apr. 20 Apr. 19	1.01 0.82 1.59
May 12	0.16	1.92	16.5	0.79	0.41	0.10	May 11 May 8 May 7	0.11 0.45 1.19
May 23	0.26	3.12	32.0	1.53	0.49	0.38	May 20 May 18 May 12	0.09 0.13 0.55
June 1	0.27	3.24	24.5	1.17	0.36	0.46	May 23 May 20 May 18	0.92 0.09 0.13
June 6, 3 p.m.	0.25	3.00	29.5	1.41	0.47	0.04	June 5 June 2 June 1	0.76 0.19 1.13
June 6, 11 p.m.	0.19	2.28	20.0	0.96	0.42	0.72	June 5 June 2 June 1	0.76 0.19 1.13
July 18	0.35	4.20	44.5	2.13	0.51	0.76	July 17 June 29 June 28	0.20 0.19 0.11

frequency he would be justified in permitting the capacity of the proposed improvement to be exceeded.

In determining the probable rate of run-off from any particular watershed it has been explained how the values of C, I, and A are determined for substitution in the equation, $Q=CIA$. As a demonstration, let it be required to estimate the run-off to be provided for in a channel in Tennessee draining a watershed area of 28 acres with characteristics similar to those of the watershed for which data are given in the accompanying table. The distance by channel is 1800 feet from the most remote point on the watershed to the outlet, and it is desired to provide capacity in the channel for such a maximum rate of rainfall as occurs once in two years.

The time of concentration for the watershed may be assumed to be the same as that given in the accompanying table for Watershed No. 1, namely, 5 minutes. Thus the velocity of flow from the most remote point of Watershed No. 1 to the outlet is $(1220 \div 5)$ 244 feet per minute. Assuming the velocity to be practically the same for the watershed of the proposed channel, then the time of concentration would be $(1800 \div 244)$ 7.38 minutes, or, say, 7½ minutes. Referring to the curves in the accompanying figure it is seen that the maximum rate of rainfall occurring once in two years for a duration of 7½ minutes is about 4.1 inches per hour. This value is found halfway between the 5 and 10-minute curves along the two-year ordinate. Now referring to the values of C obtained for Watershed No. 1, as given in the accompanying table, it is seen that these values range from 0.33 to 0.51, and for rains with rates of 4.44 and 4.20 inches per hour they are 0.41 and 0.51, respectively. Judging from these data, a value of 0.50 would be satisfactory for this watershed. For the equation $Q=CIA$ we now have $C=0.50$, $1=4.1$, and $A=28$. Making the substitutions we get $Q=0.50 \times 4.1 \times 28=$ 57.4 cubic feet per second as the required capacity of the proposed channel.

The rational method of computing storm water flow is no doubt greatly superior to the use of empirical methods and is rapidly superseding them in the design of storm water sewers throughout the United States. Even in St. Louis, the home of the McMath formula, which has also been quite generally employed in storm sewer design, the rational method has been adopted. The application of empirical formulas is simpler and require a less detailed knowledge of the characteristics of a watershed that affect run-off than the rational method. Progress, however, cannot be expected in establishing better methods of estimating run-off if engineers are inclined to close their eyes to the difficulties involved in more exact methods and are disposed to cling to the use of simpler methods at the sacrifice of greater accuracy. Available rainfall and run-off data accompanied by an accurate record of watershed characteristics for agricultural areas are extremely meager. Engineers could profitably lend their support to the overcoming of this deficiency since greater facility in the use of the rational method will follow, as the volume of experimental data expands.

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Fire Loss in Rural Communities Estimated at Third of Total

ACCORDING to figures of the National Board of Fire Underwriters, the total loss from fire, exclusive of of forest losses, in the United States in 1928 exceeded $450,000,000. Because of the fact that comprehensive statistics are not available showing what proportion of the loss occurs on farms and in rural communities, considerable effort has been made and is being made by various interested organizations to arrive at an estimate as to what share of the loss is suffered by rural districts.

At a meeting in Chicago the latter part of September the committee on farm fire protection of the National Fire Protection Association, the leadership of which has been accorded to the U. S. Department of Agriculture, endorsed the following statements:

"In the opinion of the Farm Fire Protection Committee, the loss from fires on farms in the United States is approximately $100,000,000 annually.

"It is the opinion of the committee that the fire loss on farms and in rural communities (2500 population and under) may exceed $150,000,000 annually."

"In addition to this extensive property loss there is a large rural loss of life estimated to be as high as 3,500 lives a year," says David J. Price, engineer in charge of the division of chemical engineering, Bureau of Chemistry and Soils, U. S. Department of Agriculture, chairman of the committee. "These figures suggest that practically one-third of the total fire loss in the United States occurs on farms and in rural communities, and emphasize the importance of making concerted organized efforts to reduce the losses."

Tensile Strength of Bolted, Riveted and Welded Mild Steel Joints

By J. Grant Dent[1]

DUE to the apparent lack of general information and difference of opinion on the merits of bolted, riveted and welded joints, a series of tests were made to supply some of the information.

Common mild steel, 1x¼-inch, was selected as being best suited for the tests. It was thought best to make up the bolted and riveted test pieces in the laboratory, as nearly as possible at the same time and under the same conditions. The blacksmith and oxy-acetylene welds were to be made by welders in various parts of Minnesota and adjoining states.

In starting the series of tests, ten bars of 1x¼-inch mild steel were taken at random, a piece 18 inches long cut from each and tested. (All tests were made on a Riehle Bros. 50,000-pound testing machine.) The results are shown in Fig. 1, Curve A. The 15,500-pound average was taken as 100 per cent in figuring the per cent on all succeeding tests.

Ten pieces were then cut from the bars and annealed by heating to a bright red and cooled slowly in the air. The results are shown in Fig. 1, Curve B. Because forge welding heats the metal for a considerable distance each side of the weld and because of upsetting the ends and hammering, it was thought this might increase the strength of the test piece to some extent.

Ten tests were then made using a plate six inches long of the same material, bolted on with six ¼-inch S.A.E. cap screws. The results are shown in Fig. 1, Curve C.

[1]Instructor in agricultural engineering, University of Minnesota. Mem. A.S.A.E.

In Curve D six U.S. Standard cap screws were used. These show less strength than the S.A.E. because the threads were cut nearer the head and they sheared in the thread.

Fig. 2 shows riveted joints. In Curve A a six-inch plate was placed on each side of the joint, held with six rivets. In Test Nos. 1, 2, 3, 9 and 10 the rivets sheared. The metal failed in the others. If the rivets in the end of the plates were placed in the center, the rivets sheared; if staggered, the bar failed.

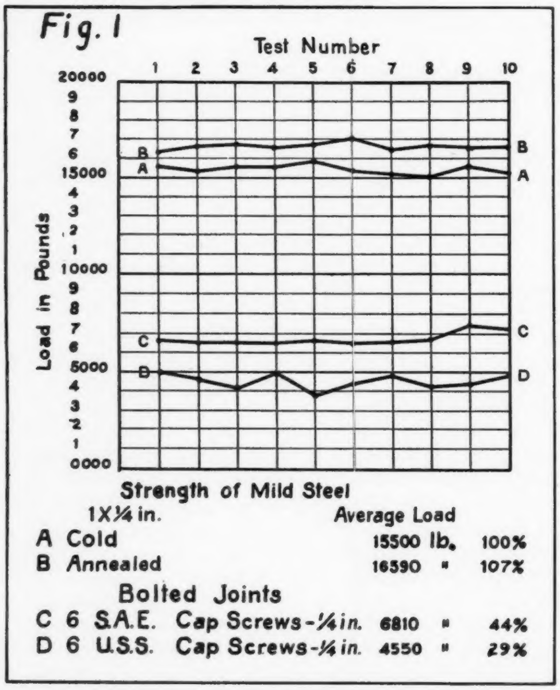
In Curve B a 12-inch plate was used with twelve rivets. In five tests the plate failed; the bar in two, and the rivets sheared in three. Curve C shows rivets put in red hot; at D and E cold.

In attempting to get welds from various welders we were insulted, sneered at and almost kicked out of some shops; while in others they were glad to make the welds and some were even willing to pay for the tests.

Approximately forty blacksmiths and about as many oxyacetylene welders were called on and each asked to make three test welds. Out of this number twenty of each consented.

The workmen were asked only to give their time as the metal was furnished, cut to length and numbered. Each man was asked to make three welds using the same methods that would be employed for any customer. They were instructed to make the weld a little oversize that it might be dressed down to the bar size before testing.

Trips were made in Minnesota and over the border into Wisconsin, Iowa and South Dakota. Some towns had



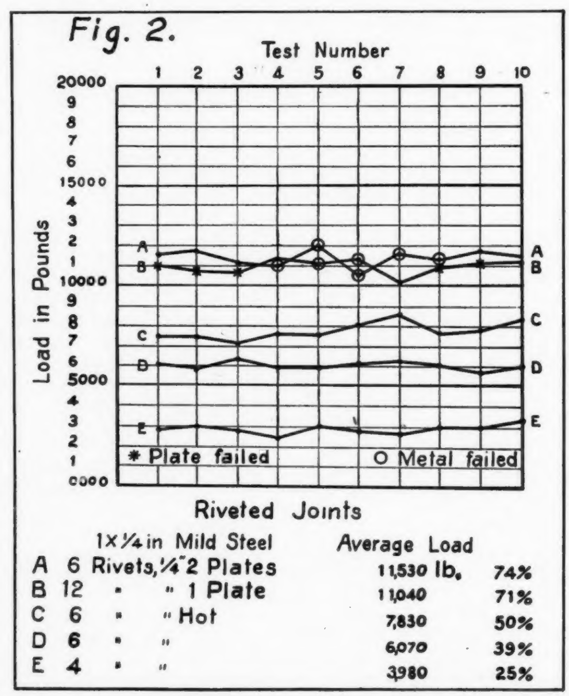


Fig. 1. (Left) Results of strength tests of mild steel and bolted joints. Fig. 2. (Right) Results of strength tests of riveted joints

TABLE I Strength Tests of Blacksmith Forge Welds

(1x¼-inch mild steel bars)

Test No.	Tensile Strength Pounds	Average Strength Pounds	Average Efficiency Per cent	Where Made
1	11,590*+	13,575	87	Welding shop
2	14,050*+			
3	15,080*+			
4	13,650 (near weld) -	14,935	96	Machine shop
5	15,760#			
6	15,390*+			
7	14,570*-	14,660	94	Machine shop
8	14,610*-			
9	14,800*+			
10	14,560 (near weld) -	12,810	83	Blacksmith shop
11	10,640*+			
12	13,230*+			
113	12,090*+	12,205	78	Blacksmith shop
14	10,470*+			
15	14,050*+			
16	12,830*+	14,170	91	Blacksmith shop
17	15,050*-			
18	14,630*-			
19	15,160*-	15,265	98	Blacksmith shop
20	14,430*-			
21	16,210*-			
22	15,970*+	15,785	100	Blacksmith shop
23	15,680*+			
24	15,710*+			
25	14,920*+	14,990	96	Blacksmith shop
26	15,470*+			
227	14,580*+			
28	10,900*-	10,340	66	Blacksmith shop
29	9,430*-			
30	10,690*-			
31	15,680*+	15,385	99	Blacksmith shop
32	15,560#			
33	15,040*+			
34	11,700*-	12,340	79	Blacksmith shop
35	13,100*-			
36	12,220*-			
37	12,930*-	14,065	90	Blacksmith shop
38	14,600*-			
39	14,670*-			
40	15,900*-	15,965	100	Blacksmith shop
41	16,130#			
42	15,870*-			
43	14,160*+	15,245	98	Blacksmith shop
44	15,560*-			
45	16,020#			
46	16,250*+	14,490	93	Blacksmith shop
47	12,850*+			
48	14,370*+			
49	14,280#	13,815	89	Blacksmith shop
50	13,350*+			
51	13,820*+			
52	9,400*+	11,250	72	Institution service blacksmith
53	12,160*+			
54	12,190*+			
55	14,720*+	14,105	91	Institution service blacksmith
56	13,330*+			
57	14,250*+			
58	12,650*+	10,075	65	Farmer-student
59	10,160*+			
60	7,420*+			
	Average	13,775	89	

(*) Failed in weld (#) Did not fail in weld (+) Soft (-) Hard

Number of welds, 60 Number of welders, 20

Average strength of cold unwelded bar, 15,500 pounds; this figure used as 100 per cent in calculating efficiency of welds. (Some tests show greater strength than the cold bar because of the annealing effect of heating the bar several inches each side of the weld. Heating to a bright red and cooling in air increases the strength of above bar approximately 7 per cent.)

Riehle 50,000-lb. testing machine used. Grips approximately 6 inches each side of weld.

Tests made by Division of Agricultural Engineering, University of Minnesota, June 26, 1928.

TABLE II. Strength Tests of Oxyacetylene Welds

(1x¼-inch mild steel bars)

Test No.	Tensile Strength Pounds	Average Strength Pounds	Average Efficiency Per Cent	Where Made
1	13,170*+	13,810	89	Welding shop
2	13,320*+			
3	14,950*+			
4	12,470*+	13,850	89	Welding shop
5	14,940*-			
6	14,150*-			
7	15,600#	15,840	100	Welding shop
8	16,060#			
9	15,860*-			
10	14,400*+	13,970	90	Welding shop
11	13,120*+			
12	14,400*+			
13	11,640*-	10,640	68	Welding shop
14	11,750*-			
15	8,540*-			
16	14,790*-	13,745	88	Welding shop
17	13,450*+			
18	13,000*-			
19	13,550*+	12,820	82	Machine shop
20	11,560*+			
21	13,360*-			
22(Ripple)	11,500*+	12,800	82	Machine shop
23(Puddle)	12,300*+			
24(P-Hammer)	14,610*-			
25	13,180*+	12,415	80	Blacksmith shop
26	11,720*+			
27	12,350*+			
28	13,910*-	13,690	88	Blacksmith shop
29	14,020*-			
30	13,140*-			
31	11,030*-	11,010	71	Blacksmith shop
32	12,150*-			
33	9,850*-			
34	7,620*-	9,365	60	Blacksmith shop
35	9,630*-			
36	10,850*-			
37	16,280#	14,615	94	Blacksmith shop
38	11,530*+			
39	16,040*+			
40	15,570#	15,610	100	Blacksmith shop
41	15,010*+			
42	16,250*+			
43	15,250*+	14,855	96	Blacksmith shop
44	14,520*+			
45	14,790*+			
46	13,930*+	13,740	88	Institution service welders
47	13,110*+			
48	14,180*+			
49	12,260*+	11,255	72	Institution service welders
50	10,060*+			
51	11,390*+			
52	13,100*+	13,520	87	Garage
53	13,460*+			
54	14,000*+			
55	14,230*+	11,980	77	Garage
56	11,410*+			
57	10,300*+			
58	9,740*-	10,400	67	Garage
59	10,360*-			
60	11,110*-			
	Average	13,000	84	

(*) Failed in weld (#) Did not fail in weld (+) Soft (-) Hard

Number of welds, 60 Number of welders, 20

Average strength of cold unwelded bar, 15,000 pounds; this figure used as 100 per cent in calculating efficiency of welds. (Some tests show greater strength than the cold bar because of the annealing effect of heating the bar segeral inches each side of the weld. Heating to a bright red and cooling in air increases the strength of above bar approximately 7 per cent.)

Riehle 50,000 lb. testing machine used. Grips approximately 6 inches each side of weld.

Tests made by Division of Agricultural Engineering, University of Minnesota, June 26, 1928.

no blacksmith shop, some no acetylene welder, and a few had neither. Many towns that had two or three blacksmith shops a year or more ago, now had only one. In some cases the blacksmith also did acetylene welding, some times being the only welder of either kind in the town. Many of the garages doing acetylene welding did only their own work.

None of the blacksmiths had attended a trade school. Only one acetylene welder had attended a short-course. A few of the acetylene welders were former blacksmiths. All of the blacksmiths making the forge welds had been in the business at least ten years and at least one over forty years. Most of the acetylene welders had been at the business less than ten years and some only a few months. Some of the acetylene welders had made a study of the process and seemed to understand what it was all about while others were just metal melters.

Many of the forge welders were absolutely sure their welds would never break, yet fifty-three out of sixty did break in the weld, as compared to 55 acetylene failures in the weld.

Nearly all of the blacksmiths and many of the acetylene welders considered the forge weld the better of the two. However, the results of this survey seems to indicate that, if the acetylene welders had had the years of experience that the forge welders have, the acetylene welds would equal the forge welds in tensile strength.

After the last of the 120 welds had been collected and tested, the results were put in table form showing the pounds tensile strength of each weld. This table was blueprinted and sent to each of those making the welds. It is planned to return part or all of the welds later. No doubt considerable benefit will be derived by the welders from seeing the results of their work and comparing them with others. Seeing the defects in the broken welds should also be helpful. Some requests for a second try have been received and one blacksmith who got a 90 per cent average on his first three forge welds got 97 per cent on his second lot. Only the first trials are recorded in this survey, however.

Cost of Welding. As the welds were being collected, data was also taken on prices charged for regular commercial work of this size. Some shops where the work was guaranteed charged as high as 35 cents each. The average price asked was 25 cents each for either kind of weld.

Summary

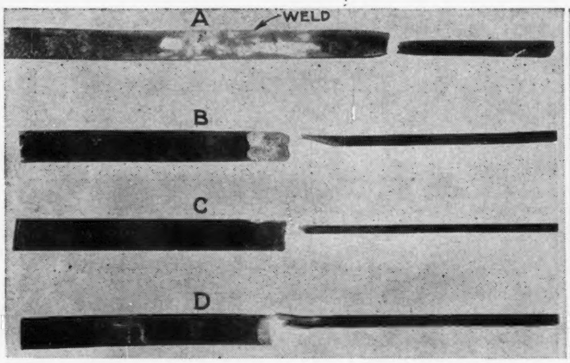
Blacksmith Forge Welds. Of the sixty welds tested, fifty-three failed in the weld, most of them along the line of the weld all or part way. Of the seven welds which did not fail, five were not affected by the strain, the bar necking down and failing several inches from the weld (See A, Fig. 3). The other two failed about one inch from the weld. Two out of the twenty welders got 100 per cent averages. The average for the sixty welds is 89 per cent.

All welders upset and scarfed the two ends. All except one used a commercial flux. This man did not use a flux. All welders were instructed to air-cool their welds.

The pieces were lapped from ½ to 1½ inches and hammered nearly down to size. The short lap tests were

Tensile Strength of 1x1¼-inch Mild Steel Bars and Joints

Kind of Joint	Average, pounds	Per cent
None (plain bar)	15,500	100
None (annealed)	16,590	107
6 S. A. E. ¼-inch cap screws	6,810	44
6 U.S.S. ¼-inch cap screws	4,550	29
6 rivets, ¼-inch, 2 plates	11,530	74
12 rivets, ¼-inch, 1 plate	11,040	71
6 rivets, ¼-inch hot	7,830	50
6 rivets, ¼-inch cold	6,070	39
4 rivets, ¼-inch cold	3,980	25
Forge weld	13,775	89
Oxyacetylene weld	13,000	84



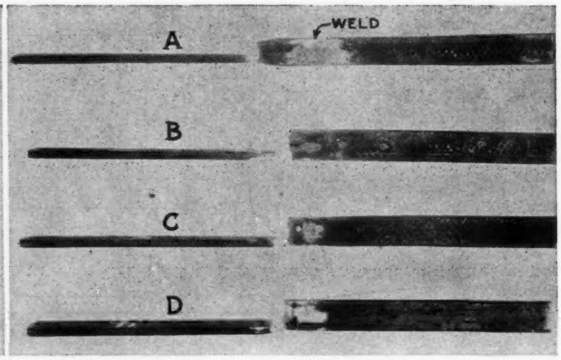


Fig. 3. (Left) Types of failure in forage welds. Fig. 4. (Right) Types of failure in oxyacetylene welds

very poor. All welds were ground and filed to the bar size before testing. The testing machine grip seized the bar approximately 6 inches each side of the weld. The bars commenced stretching at from 11,000 to 12,000 pounds.

Overheated and slightly burned welds were stronger than the underheated ones. Nearly all of the welds pulled apart along the line of weld without tearing the metal except at the scarfed ends and sometimes not even there (See B, C, and D, Fig. 3). This would seem to indicate that the metals were nearly always underheated. The line of weld showed rather plainly before testing in many cases.

Clean orderly shops usually turned out the best jobs and in almost every case the man taking more time boasting about his work than it took to make the three welds, was one of the low men. The time required to make the three welds ranged from 10 minutes to 1½ hours. Both of these extremes were low tests.

Oxyacetylene Welds. Of the sixty welds, fifty-five failed in the weld. The five welds which did not fail were not effected by the strain and the bar failed a considerable distance from the weld (See A, Fig. 4).

Two welders got 100 per cent average on their welds, as compared with two forge welders. Both these acetylene welders conducted welding shops and used the butt method, puddled and lightly hammered. Nearly all welders ground the metal to a V on each side and practically all of these showed a poorly welded streak through the center. The few who butt-welded backed the ends apart from ⅛ to 3-16 inch. The better workmen seemed to favor a large welding tip, completing the job much quicker than where a small tip was used.

Nineteen out of the twenty acetylene welders used commercial mild steel welding rods. One used a common mild steel rod and made an average of 82 per cent in the tests. Those who used the puddle method got better results than the ripple, and lightly tapping the white hot completed weld with a hammer seemed to add strength

Acetylene welding heated the bar only a short distance from the weld while the forge fire anneals the bar for a considerable distance. Some of the acetylene welders did not weld with a neutral flame and many of the welds showed effects of burning. The grip of the testing machine seized the bar approximately 6 inches each side of the weld. The average tensile strength of the sixty acetylene welds was 84 per cent as compared to 89 per cent for the forge welds. No tests were made of electric welds because of the scarcity of welding machines in the smaller towns.

New Theory on Cause of Spontaneous Ignition

A NEW theory as to the cause of the spontaneous ignition of hay and other farm products, one of the most mysterious causes of farm fires, is advanced by Dr. Charles A. Browne of the U. S. Department of Agriculture in Technical Bulletin 141-T, "The Spontaneous Combustion of Hay," just issued by the department as its first publication on the subject.

Doctor Browne, who is chief of chemical and technological research in the Bureau of Chemistry and Soils, believes that spontaneous ignition is due not only to heat developed by bacterial action but to the much higher temperature following the oxidation of certain compounds produced by the bacteria.

It is well known, Doctor Browne explains, that the primary step in the heating of hay is due in large part to enzymic and bacterial action which causes a breaking down of the carbohydrates and other substances of the stored material. This is commonly known as fermentation or decay. These vital processes, however, are mostly destroyed by heat at about 150 degrees Fahrenheit, and the rise of temperature from this point to the 600 degrees or more necessary for ignition, has been a puzzling problem of chemistry.

Doctor Browne's theory is that bacteria produce certain unstable, unsaturated compounds which by their greater affinity for atmospheric oxygen raise the temperature not only to the death point of the bacteria but to the point of ignition. The process is purely chemical and is comparable to the familiar example of spontaneous ignition of cotton waste when coated with an unsaturated substance such as linseed oil.

Doctor Browne explains that gaseous products formed in the interior of a heating stack exert an outward pressure from the centers of chemical activity, or so-called "hot-pockets," creating flues or channels. When such a flue reaches the surface of the stack, there is a sudden inrush of air to the hot pocket. The ensuing oxidation of the hot unsaturated products of bacterial decomposition causes such a rise in temperature that ignition readily takes place. In case the pressure of gases is insufficient to open a passage for the entrance of large volumes of outside air, oxidation proceeds at a much slower rate and there is only a charring of the hay without ignition.

A determination of the exact chemical processes involved in spontaneous heating is necessary for the development of effective storage methods for farm products to reduce loss from fire or spoilage, says Doctor Browne. He emphasizes the need for extensive cooperative experiments on the subject by chemists, bacteriologists and engineers.

Copies of the bulletin may be obtained by writing to the U. S. Department of Agriculture, Washington, D. C.

Research in Mechanical Farm Equipment—1928[1]

By R. W. Trullinger[2]

THE development of effective investigations in farm machinery, farm power, and related subjects during the year speaks well for the efforts of the (U.S.D.A.) Advisory Council on Research in Mechanical Farm Equipment. The growth of well-directed inquiry into these subjects is reflected in the fact that seventeen Purnell studies of mechanical farm equipment were active during the year at eleven agricultural experiment stations. The Louisiana station led with three; the South Dakota, Montana, and Pennsylvania stations had two each, and the Georgia, Massachusetts, West Virginia, Alabama, Nebraska, North Dakota, and California stations had one each. The subjects dealt with were seeding machinery; fertilizer distributors; combines; traction machinery; tillage machinery; corn harvesting machinery; artificial hay curing equipment; cane milling machinery; the development of power and labor-saving machinery for growing corn, soy beans, garden vegetables, potatoes and hay; soil dynamics as related to tillage implement design, and bearing wear in tractor engines as related to lubrication. In addition the Alabama station continued the Adams fund study of the influence of soil dynamics on traction.

A record of the total number of mechanical farm equipment projects active at the agricultural experiment stations during the year is not available. However, during the previous year the total number active was eight-five, so far as can be determined. From the results of official visits to the stations during the year there is evidence that, in several cases at least, the total number of mechanical equipment projects was materially increased, and in several cases the work was strengthened by the revision of existing projects along more sound lines or by the substitution of new or stronger projects for old ones. Several foreign research agencies seemed also to have caught the spirit and undertook rather profound studies of mechanical farm equipment.

It is impossible to completely review the progress of all the work done in the subject in this country and abroad during the year. However, attention is drawn in the following to a few of the outstanding results to indicate the progressive trend.

TRACTION MACHINERY

Considerable progress was reported during the year in the development of traction machinery with particular reference to the improvement of specific features to better adapt available traction devices to the difficult and severe conditions imposed by agricultural operations. The tractor tests conducted at the Nebraska Agricultural Experiment Station seemed to have deviated somewhat from the usual practice of routine testing in order to establish certain fundamental principles. In this connection several improvements in tractors have been brought to light. For example, the fuel consumption records indicated a decided improvement in the past few years. In 1927 the average figures were 9.8 horsepower-hours per gallon of fuel, or 0.68 pounds per horsepower-hour. The power available for a given weight of tractor has been materially increased, varying from a static weight of 356 pounds per drawbar horsepower in 1920 to 233 pounds per drawbar horsepower in 1927. Drawbar efficiency has increased from an average of 69.2 per cent in 1920 to 74.9 per cent in 1927. The rate of travel has increased from an average of 2.49 miles per hour in 1920 to 3.25 miles per hour in 1927. At the beginning of the tractor testing season of 1928 a new procedure was incorporated in the method of testing tractors which involved the use of one carburetor setting for all tests, whereas formerly the carburetor was adjusted for each test. This change makes the test results more nearly correspond to results obtained in the field by the average operator and introduces uniformity into the testing. The results indicate the possibilities and advantages of a carburetor designed to operate economically over a wide range of loads without changing its adjustment. They also indicate that the manifolding should be verified by actual tests before final adoption since the beneficial results of a good carburetor may be almost lost if used in conjunction with a poor manifold.

In tests of tractor wheel equipment the Pennsylvania station found that rubber-tired wheels without chains provided sufficient traction for general field work other than

[1]Paper presented at the power and machinery session of the 23rd annual meeting of the American Society of Agricultural Engineers, at Dallas, Tex., June, 1929.

[2]Assistant in experiment station administration, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture. Mem. A.S.A.E.

Over 40,000 acres, of a total of 125,000 acres of land in the Everglades of Florida owned by the Southern Sugar Co., have now been placed under complete water control. This year 12,000 acres are to be planted to sugar cane—entirely by mechanical power. This development was started not only to produce sugar but to secure a supply of bagasse (the waste pulp) for making a building and insulating material (Celotex). This picture shows one of a fleet of "Caterpillar" tractors on this project hauling track-type trailers loaded with cane

plowing only under the most favorable conditions. A little moisture on the surface caused the wheels to spin. However, a tractor equipped with rubber-tired drivewheels and metal front wheels could be driven at 4 miles per hour over rocky farm roads with perfect comfort to the operator. Rubber-tired front wheels made steering difficult. The ground appeared to be packed more by rubber-tired wheels than by any metal wheels. Spade lugs on an 11-inch rim gave the best traction of all wheels tested, both on plowed ground and on sod. Angle lugs on a 6-inch rim gave practically the same traction as the open wheel with cone lugs.

In a continuation of the study of the fundamental factors influencing the traction of wheel tractors the Alabama station established correlations between laboratory data and field results with actual tractors. In plaster cast studies of force distribution in soil a comparatively close check was obtained between calculated and actual distortion. The weight on the wheel and the depth of the lug are functions of the direction and amount of soil distortion. Shear in the soil takes place perpendicularly to the resultant of lug and rim displacement. By taking advantage of the arch action of the soil the lines of shear can be given greater distortion through the soil, resulting in a greater drawbar pull by the tractor.

The California station found that a properly selected drawbar spring can give satisfactory overload protection at low and medium tractor speeds, if the implement is designed to withstand safely a drawbar pull of 1.5 to 2 times the maximum tractive ability of the tractor. At higher speeds a spring is not practical to replace the breakpin, but springs may be used to reduce stresses resulting from increased loads or speed, and thus reduce the frequency of breakpin replacements. The effectiveness of a spring strong enough not to be completely compressed in preventing increase in the drawbar pull varies as the value of the speed of the tractor times the square root of the product of its weight and the load deformation ratio of the spring. Studies of spring-held overload release hitches showed that such hitches should have uniformity of pull for release at given adjustments and this pull should be proportional to the adjustment.

The above results are typical of efforts being made to meet the conditions and requirements for traction in agricultural operations. Evidently there is much need for further development of available traction machinery along specific lines. A knowledge of the requirements to be met in each operation is obviously of considerable importance, and the necessity for a coordination of effort with the subject-matter specialists in agriculture seems without question.

INTERNAL-COMBUSTION ENGINE FUELS

Considerable work was reported during the year on the development of fuels for use in internal-combustion engines which for the most part was done by agencies other than agricultural engineering. Attention was drawn in a recent report by Col. O. B. Zimmerman[3] to the importance of this subject in connection with the development of agricultural traction machinery along both efficient and economical lines .

With reference to the use of alcohol as an internal-combustion engine fuel the California station reported the finding that most farm gas engines on the present American market can be operated with mixtures of gasoline or kerosene and alcohol without structural changes. Mixtures of alcohol with either gasoline or kerosene were found to have less tendency to deposit carbon than either kerosene or gasoline alone, and also less tendency to dilute the oil. Smoother operation was also secured. The Australian Council of Scientific and Industrial Research, however, reported the finding that the necessary raw materials are, in general, too valuable as foodstuffs to permit their distillation into power alcohol. It appears, however, that in certain parts of Australia raw materials can be produced at such a cost as will enable any alcohol distilled from them to complete locally with gasoline.

Considerable work was done by various agencies on methods of knock suppression in fuels. The University of Iowa, for example, demonstrated the value of nickel colloids in this connection. The University of Birmingham in England found that certain pure hydrocarbons have appreciable knock-suppressing qualities. The University of Illinois reported that a compound to have suitable antiknock properties must be an inhibitor of gas-phase oxidation and an accelerator of liquid phase oxidation. Studies conducted at Yale University indicated that the carbon-removal saving resulting from the use of a fixed doped fuel is highest for the lowest compression ratio, and vice versa. The fuel saving has a definite relationship with compression ratio and is directly proportional to the cost of fuel for any compression ratio. It appears that the economy of the use of doped fuel at a compression ratio of 5 to 1 depends entirely upon carbon-removal saving, a low cost of carbon removal and long mileage before removing carbon, making the use of doped fuel uneconomical, and vice versa. The University of Toronto drew the further conclusion that there is no economic advantage in buying antiknock fuels at a three-cent premium if an engine having a compression ratio of 5.5 to 1 can be operated satisfactorilw on ordinary gasoline. It was also found that there is no gain in power or economy by using special lubricants in fuels.

The above typical results suggest that much is yet to be learned regarding fuels for internal-combustion engines. Since power for traction is one of the large items in the cost of agricultural production, it would seem worth while for agricultural engineers to give some consideration to the fuel development problem, with particular reference to the requirements of specific power operations.

TILLAGE MACHINERY

Several developments took place during the year with reference to tillage and tillage machinery. The Alabama station, in continuing its studies of the influence of soil dynamics on the design of tillage machinery, found that the adhesive properties of tillage implement metal can be varied by various heat treatments. In fact, rapid cooling of the metal from the nonrigid state in mercury resulted in the lowest adhesion of soil to the metal surface. The importance of these findings from the standpoint of the power requirements of tillage can not be overestimated.

A private agency in reporting the results of a large number of tillage experiments emphasized the importance of the physical aspects of soil organic matter in this connection. A constantly increasing content of organic matter in the soil, regardless of its nature, was found to result in a corresponding decrease in the amount of power required to pull a plow whether the ground was dry and hard, or in ideal condition for plowing. A nonscouring condition in acid soil could be cured by the correction of the acidity and by increasing the organic matter content regardless of the size or shape of the plow. In this connection the New Jersey station reported that the plowing draft of a soil tends to increase as the crop yield increases, due to the heavier root development and the greater resistance to the plow by soils of higher fertility. It was found, however, that the draft required to plow limed soils is less than that for nonlimed soils in spite of the normally higher yields following the liming of soils and the consequent increase in root developing of soils and the consequent increase in root development. The Arkansas station concluded from 500 plow draft tests that the draft per unit area of furrow section is in-

[3]Agricultural Engineering and Fuel Research (Agricultural Engineering, 1927, Vol. 8, No. 12, pp. 349-350).

Tractor cultivating five rows of cotton with cultivators originally designed for two rows each. Note center extension shovels which cultivate the middle row. Two men cultivate sixty acres per day with this outfit

versely proportional to the depth of cut and to the width of plow bottom.

Some progress was made at both the Iowa and Indiana stations in the development of rotary tillage devices. At the former station a measure of success was secured with a machine in which the moldboard of a standard plow is replaced by a revolving pulverizer head having blades which engage the furrow slice and beat and mix the soil. The reduction of drawbar horsepower under that required for a plow is sufficient to furnish a large part of the power needed to drive the pulverizer.

The above typical findings relating to the development of tillage machinery suggest the importance of cooperation with agronomists and soil technologists in determining the requirements of specific soils for tillage as a basis for the development of tillage implement parts.

HARVESTING AND THRESHING MACHINERY

It is being recognized that the development of satisfactory and economical methods and equipment for the harvesting of crops calls for the coordination of the forces of agronomy and agricultural engineering in studies of conditions and requirements for harvesting, with the idea of adapting available machines or of developing the principles of new ones which will perform this operation satisfactorily. This is particularly true in the harvesting and threshing of grain, and considerable work was done during the year with the combining procedure for the purpose of showing in what specific details available combine machinery falls short of satisfactorily, as well as economically performing the necessary operations.

The North Dakota station found, for example, that any good combine when properly adjusted will thresh all the grain from dry wheat heads. When the grain contains green weeds the power requirements for combining were increased since the weeds clogged the elevators and screens and interfered with the threshing and separator operations. A more serious drawback was the moisture added to the otherwise dry grain either by green weed seeds, particles of green weeds, or juices mashed from green weeds as they passed through the combine.

The Pennsylvania station found that the combine method effected a considerable saving in the cost of harvesting wheat and oats when the straw was left on the field, but when the straw was removed it cost more to harvest by this method than by binding and threshing. Studies of the effect of weather conditions on the moisture content of standing grain showed that no definite hour in the morning for starting the combine is indicated since it appears to depend entirely upon weather conditions.

The Canada Experimental Farms reported the introduction of the swather attachment in the use of the combine. In this connection the Minnesota station found that the use of the windrower is almost indispensable when combining a weedy field. The Missouri station found that the windrowing system reduces the trouble due to high moisture content and tends to lower threshing losses in weedy grain. The California station reported progress in the development of methods and equipment for the efficient and economical handling of grain in bulk, especially wheat, barley and rice. The bulk storage of rice without heating was successful. The Michigan station found that beans can be harvested and threshed with regular combine equipment with certain changes and adjustments, such, for example, as a wider spacing between the cylinder teeth and the concave teeth. It also appears desirable to use a special bean cylinder and concaves where large acreages are harvested.

The Pennsylvania station reported that harvesting requires from 42 to 54 per cent of the total labor required in producing a potato crop in the state. Picking up the potatoes, which is now entirely a hand operation, requires from 26 to 33 per cent of the labor required in producing the crop. Engine-driven potato diggers were found to do better work than traction-driven diggers, and mechanical pickers were unsatisfactory under Pennsylvania conditions, due to the difficulty of securing soil and stone separation and the heavy yields. It appears that lower forward speeds are necessary with high yields if mechanical potato pickers are to be used.

GRAIN CLEANING MACHINERY

The proper cleaning of grain is asuming considerable importance in the production of grain crops. The U. S. Department of Agriculture found during the year that part of the weed seeds in grain can be removed with present types of grain cleaners available for combines if the windrow method of harvesting is used.

The Reichskuratorium for Technical Agriculture of Germany has pointed out that grain-cleaning equipment should provide at the outset for dust removal. A windblast sorting device for separation of the grain kernels according to their specific weights is also a desirable feature. In addition, sieving apparatus for sorting according to size and equipment for sorting according to the shape of the kernels are desirable. The results of experiments also suggest the advisability of means for treating the grain for protection against fungous diseases. It has been found that air blasts tend to separate grain kernels according to size, due primarily to the relatively greater surface friction of the small kernel.

CROP DRYING EQUIPMENT

The importance of maintaining superior quality in crops regardless of the conditions under which they were harvested has received considerable emphasis in recent work. The New York Cornell, Virginia, Indiana, and Illinois stations especially have been active in this connection. At the Virginia station experiments on grain drying by natural ventilation indicated the promise of simple, naturally ventilated bins for eastern farmers using the combine. An outstanding finding was the close relation between the moisture content of wheat and the relative humidity. It appears that rainfall does not affect the moisture content of standing wheat except as it causes a change in the relative humidity.

The Illinois station, in continuing the corn-curing experiments, found that a drying temperature of 130 degrees (Fahrenheit) did not lower the germination percentage of corn, but a temperature between 140 and 150 degrees materially decreased germination. However, there appears to be no objection to the use of a drying temperature as high as 150 degrees for corn used in livestock feeding. The Indiana station was able to dry out moist corn and make it fit for permanent storage at a cost of fuel of 3 cents per bushel.

The Division of Agricultural Engineering of the U. S. Department of Agriculture found that wheat could be reduced in moisture content from 18 to 14 per cent in from approximately 40 to 80 minutes, depending largely upon the rate at which heat was applied. The number of British thermal units supplied by the heater in drying the grain varied from 14,320 to 10,240 per bushel. The results also seemed to show that the quantity of air forced through the grain is significant only in so far as it affects the number of British thermal units supplied. It appears that the heat requirements for drying wheat are equivalent to about 1 pound of coal per bushel of wheat at 100 per cent efficiency for the heating unit.

Rice drying studies by the California station showed that bound rice placed in shocks lost most of its moisture during the first 80 hours after cutting, while bundles laid flat on the stubble dried out a similar amount in from 50 to 55 hours. Very little moisture loss occured after these periods.

These typical undertakings recognize the requirements of the finished products as determined by agronomists, and are endeavoring to meet them satisfactorily with the aim of increasing the value of the resulting crop.

DAIRY EQUIPMENT

The proper development of different types of dairy equipment along lines of efficiency and economy is assuming considerable importance. During the year the California station, for example, established the thermodynamic equations involved in the heating of milk cans over steam jets. The results of the tests indicated that wet or saturated steam is best for the first steaming, but that this should be followed by a second heating with superheated steam for satisfactory results in a can washer. The superheated steam left less moisture to be removed than did wet or saturated steam. In the same connection the Reichskuratorium for Technical Agriculture of Germany obtained mechanical, bacteriological, and chemical results which, as a whole, indicate the superiority of mechanical cleaning over hand cleaning for the inside of milk cans, and the superiority of hand cleaning for the outside of the cans. It appears, however, that the internal cleaning by mechanical means is still far from perfect and considerable research is necessary to correct the defect of available methods and equipment.

The work at the California station with a large size steam-type electrically heated dairy sterilizer showed that good bacterial reduction was possible and that the heating was sufficiently rapid for practical purposes. Prompt withdrawal of the equipment from the sterilizer was found to be desirable to avoid rusting. These typical studies indicate the necessity of coordinating the efforts of agricultural engineers with dairy bacteriologists and chemists in the solution of dairy equipment problems.

In addition, work was done at the California station on the development of solar heaters to utilize solar energy for heating water for dairy and household purposes. Data taken in northern California on a bright sunshiny day between the hours of 8:00 a.m. and 5:00 p.m. showed an average absorption of 2.23 British thermal units per minute per square foot of exposed area by a single glass-covered stationary absorber. It was possible to increase the efficiency of this type of absorber approximately 15 per cent by embedding the coil in cement plaster having a black painted surface exposed to the sunlight. The Alabama station also developed a device which uses the energy of the sun for heating water consisting of three 30x60-inch sections built of corrugated roofing riveted to flat roofing and so arranged that the water will pass between the two middle surfaces. The heater is covered with glass. The water temperature obtained in the months of August, September, and October ranged from 90 to 150 degrees, providing water in sufficient quantities for the use of a dairy of thirty cows.

MISCELLANEOUS MACHINERY

Considerable work was done during the year in the development of miscellaneous mechanical processes and equipment along cost-saving and profit-creating lines.

With reference to the grinding of feed, for example, the Indiana station has found that grinding whole grain in the ration for dairy cows increases production 8.5 per cent but that excessively fine grinding does not pay. Similar results were obtained with reference to the grinding of grain for hogs. Grinding was found by the Idaho station to be a profitable method of preparing alfalfa and other farm crops and by-products for cattle feeding. Ground alfalfa hay gave better results than short-cut or long hay as cattle feed, and waste was reduced. The results were not so good with feeding lambs, however, indicating the importance of close cooperation with the animal nutrition specialist in work of this character.

The Agricultural Academy of Berlin has done some work on the tractive resistance of farm wagons which is worthy of mention. The results with the two-wheel wagon on five different soil types indicated that tractive resistance depends mainly on the wheel dimensons on both light and heavy soils, the draft decreasing as the wheel diameter increases. Four-wheel wagons with the same loads and wheel dimensions showed a lower draft than did two-wheel wagons. A uniform distribution of the load over front and rear wheels of four-wheel wagons was also in favor of lower draft. The results also showed the value of roller bearing axles and dustproof hubs. It is significant that the work throughout was controlled by the conditions of practical farm hauling.

Work by the same institution on the power requirements of a mower indicated that as a whole the efficiency of a mower decreases with increasing speed. It appears that a relatively large proportion of the power required in the operation of a mower is expended in overcoming the inertia and friction of the machine itself. The frictional losses were found to increase almost with the cube of the speed. The favorable influence on power requirements of proper shaping of the sickle teeth, exact alignment of the crankwheel, the use of antifriction bearings and proper balance of the crankshaft and pitman, was demonstrated. At a forward speed of about 8 feet per second the power required was normally about 7 horsepower. However, as the hay became more tough or tangled this requirement could easily be increased to 9 or 10 horsepower and the efficiency of the mower decreased accordingly. The necessity for a thorough consideration of the requirements of the crop to be cut is thus clearly demonstrated.

CONCLUSION

The above brief review of typical outstanding results of mechanical farm equipment studies during the year points to the importance of clarifying and defining a field of research. That process, as applied to mechanical farm equipment, has revealed the existence of a large number of important mechanical problems in programs of agricultural research, the most of which materially affect the economy and efficiency of some line of agricultural production. In most instances noted above the need for engineering investigation arises from some very definite agricultural problem. Such participation may require the testing or comparing of available equipment, or the development of new equipment on the basis of known standards or established requirements. It may even call for original research to establish the fundamental principles involved in a practice, such as tillage or traction, for example, to provide a basis for the rational development of the necessary equipment. In practically every instance, however, the proper line of attack calls for the coordination of the efforts of agricultural engineers with those of agronomists, soil technologists and other subject-matter specialists, in the study of specific mechanical problems.

The Installation of Farm Water Systems[1]

By J. P. Schaenzer[2] and F. W. Duffee[3]

RUNNING water in the farm home and farm buildings probably ranks second only to electric lights as a farm convenience. Electricity from a central station or individual plant is the ideal power for a farm water supply system as with it the system can readily be made entirely automatic.

A pump capacity of 200 to 400 gallons per hour will meet most farm conditions. Pressure tanks for hydropneumatic systems are commonly furnished in sizes of 40 gallons and larger. A tank of 120-gallon capacity is ample for ordinary conditions. Where the system is automatic, it is not necessary to have a tank of larger capacity. A small tank will be refilled oftener and consequently the water will not get as stale or warm in hot weather.

A galvanized tank is preferred as the water will be better for drinking purposes. The smaller sizes are usually furnished in galvanized steel only, but the larger sizes are commonly furnished in black steel.

Common types of farm water supply systems for both deep and shallow wells and cisterns are: (1) gravity, (2) hydropneumatic is the most popular. The principal parts matic, (4) air power, and (5) Michigan.

The combined hydropneumatic and gravity, the hydropneumatic, and air-power and Michigan systems are recommended for electric power. When the gasoline engine is used the combined hydropneumatic and gravity, the gravity and air-power systems are suitable. The windmill and hydraulic ram adjust themselves to the gravity system only.

Of all the complete automatic electric systems, the hydropneumatic is the most popular. The principal parts of this system are:

1. A good force pump and brass cylinder
2. An electrically-driven jack or other source of power. The motor, jack and pump are usually constructed as a unit in electric systems which insures efficiency and correct alignment of all working parts
3. A steel pressure tank tested to withstand a pressure of about 100 pounds per square inch
4. An air dome, a good quality disk check valve, a water relief or safety valve, an air compressor attachment, and an automatic electric pressure switch
5. Necessary pipe and fittings.

In operation water is pumped into the bottom of the pressure tank, trapping and compressing the air in it. This compressed air supplies the necessary pressure to force the water throughout the system. The advantages of the system are:

1. It supplies excellent pressure throughout all the farm buildings, furnishing an automatic supply of water for the farm equal to city water service
2. It supplies pressure for a hose and gives a limited amount of fire protection
3. A comparatively small and inexpensive storage tank of 40-gallon or larger capacity is satisfactory with an automatic electric system. A 120-gallon tank is recommended
4. The tank can be conveniently located in the well pit, or basement, and in either of these locations the water keeps fresh and will not freeze
5. This system is not as expensive to purchase or operate as the air-power system and only a trifle if any more expensive than a gravity system.

The disadvantages of this system are:

1. If, for some special reason, a larger storage capacity is necessary, the storage tank will be expensive. The combined hydropneumatic and gravity system has been designed to economically meet the demand for large storage
2. The cost of fuel or electric energy will be slightly greater for a hydropneumatic than for a gravity system due to the greater pressure. However, this difference is slight as the total cost of pumping water is small.

The hydropneumatic system must be equipped with some device for replenishing the air in the pressure tank. When the automatic switch stops the pump at a pressure

[1]Paper presented at a meeting of the Rural Electric Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

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[3]Associate professor of agricultural engineering, University of Wisconsin. Mem. A.S.A.E.

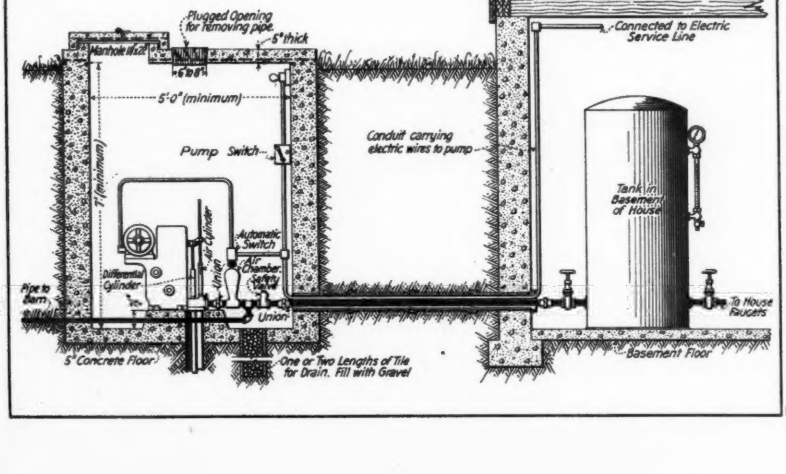

Fig. 1. An Automatic electric hydropneumatic water system for a deep well where the distance from the well to the house is more than 50 feet, it is recommended to place the pressure tank in a pit. The pipe from the well to the tank should be as short and straight as possible with a gentle upward slope toward the tank. By placing the pipe and wires in the sewer pipe, they can readily be removed for repairs in case of trouble

of approximately 40 pounds, the tank should be about two-thirds full of water and the upper one-third filled with compressed air. The automatic switch is usually set to start the pump again at about 20 pounds pressure. At this time the tank is about one-third full of water; thus the working capacity of the tank is about one-third of its total capacity.

If the pump and pressure switch is located a considerable distance below the house or barn, the pressure at the faucets will be less than the 20 to 40 pounds. It is possible to adjust the switch to take care of this additional distance or elevation.

The air that was in the tank originally will be absorbed by the water and drawn out with it, so that in time the tank becomes water-logged unless additional air is supplied. Under these conditions the pump will start and stop frequently.

All hydropneumatic pumping systems are equipped with one of three devices for maintaining the required supply of air in the pressure tank: An air pump, a hydropneumatic cylinder, or, in the case of shallow well suction pumps, an air snifter valve.

Branch line connections installed between the pump and the pressure tank must branch out at the bottom of the pipe. In case a fresh-water faucet is desired in the kitchen or elsewhere all that is necessary is to insert a so-called fresh-water check valve and a tee in the pipe line between the pump and the pressure tank and run a pipe from this tee to wherever the fresh water is wanted.

When the faucet is opened, the pump starts. A swing check valve is used with a 1-32-inch hole drilled through it or a slot cut into the seat of the valve. The opening in the check valve helps to maintain the pressure on the automatic switch in case of leaks and prevents the pump from starting every few minutes.

The combined hydropneumatic and gravity system is one of the most practical and satisfactory types for electric operation. The principal parts are: (1) An automatic hydropneumatic system; (2) a gravity storage tank in the hay mow or other convenient place, and (3) a shut-off valve in the main pipe line coming from the pressure tank. It is opened to fill the gravity tank. A valve just below the tank is also desirable. With this arrangement the various faucets can be supplied directly from the pressure tank. A float valve may be placed in the tank to regulate the flow of water automatically.

The advantages of this combination system are:

1. The gravity storage tank gives cheap storage for a fairly large amount of water. This is an insurance against interruptions of the electric service or pump trouble
2. The gravity tank gives low pressure in the barn. Many drinking cups will squirt badly under the higher pressure of a pressure tank. They will also be more apt to leak
3. The hydropneumatic pressure tank gives high pressure at the house.

One disadvantage of the system is the extra expense involved.

Gravity systems are especially well adapted to windmill or gasoline engine-driven pumps. They are not recommended where electricity is available. The principal parts of the system are: (1) A good force pump, (2) one or more elevated tanks, (3) a gas engine, windmill or other source of power and a pump jack, (4) an electric float switch, if electricity is the power used, and (5) necessary pipe and fittings.

The advantages of the gravity system are: (1) It may be somewhat cheaper to install than the other systems, and (2) the cost of operation will be slightly less than for a hydropneumatic system.

The disadvantages of the gravity system are: (1) It is difficult to secure sufficient elevation to give satisfactory pressure at the faucets; (2) it is almost impossible to keep the water fresh; (3) there is danger of the tank

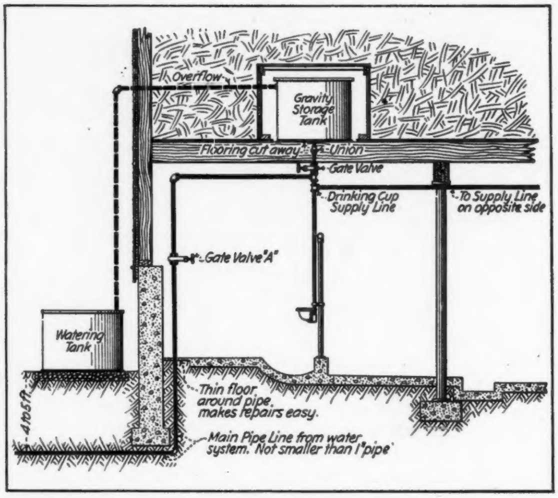

Fig. 2. A gravity system for the barn. An ordinary stock tank can be used. The gravity tank insures the user of an extra supply of water in case of an emergency. Some drinking cups will leak and squirt if fed from a pressure tank. Gate valve "A" is used for filling the tank.

freezing in the winter time; (4) heavy construction is required to support the large tank, and (5) leaks in a gravity tank, if located in the house, may do serious damage.

The air-power system, or the fresh water system as it is frequently called, delivers water directly from the well to the faucets using compressed air to operate the pump. Important parts of this system are: (1) A gasoline engine or electric motor, (2) an air compressor, (3) a storage tank for compressed air, (4) a pressure-reducing valve and safety valve, (5) one or more pneumatic cylinders, and (6) necessary pipe and fittings.

The pneumatic cylinder is located in the well below the surface of the water. There are two pipe lines to this cylinder; one carries compressed air from the compressed air storage tank through a reducing valve to the cylinder, and the other delivers the water from the cylinder to the faucets. In this system the motor, compressor and tank usually come as a complete assembled unit and may be located in any convenient place.

The advantages of this system are: (1) One compressor unit and air storage tank will supply both hard and soft water by providing an extra cylinder; (2) fresh water is supplied at all faucets after the pipes are drained, and (3) the power unit and compressor may be placed at any convenient place.

The disadvantages are: (1) It will not economically raise water more than 100 feet; (2) it is more expensive to operate than either the hydropneumatic or gravity systems, and (3) the initial cost is considerable more than for the other systems.

The Michigan system is an inexpensive and serviceable system for electric operation developed by H. J. Gallagher of Michigan State College. An underground pipe is run from the lower connection on the windmill type of force pump to the kitchen sink. The motor is controlled through two three-way switches, either one of which will start or stop the motor. One of these is located just above the kitchen sink and the other at the pump. The three-way valve on the force pump should be left in the "house discharge" position all of the time, except when water is being drawn at the pump to fill the stock tank. When it is left in this position, water can be drawn at the kitchen sink by merely turning the switch. Faucets should not be used.

The advantages of this system are: (1) It is inex-

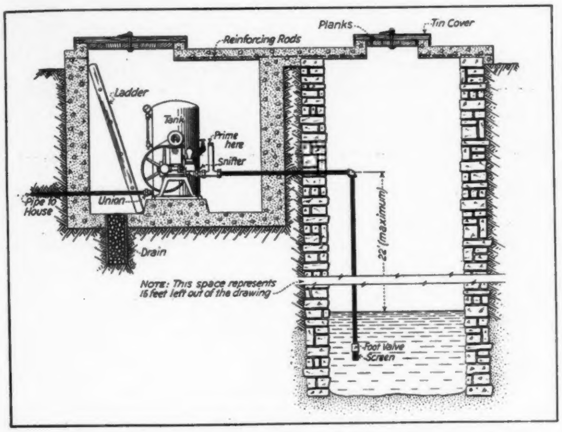

Fig. 3. An automatic electric hydropneumatic water system for a. shallow well. This system can be used where the depth to water does not exceed 22 feet. The pump may either be placed in a pit or the basement of the house, if the distance is not more than 100 feet. A shoulder is placed around the manhole to keep water from running into the pit. The covers are made of planks, covered with tin which comes over the shoulder of the manhole

pensive and simple to install; (2) it may readily be changed to a complete, automatic hydropneumatic system, and (3) it supplies fresh water.

The disadvantages are: (1) It requires more attention to operate than automatic systems; (2) water cannot readily be drawn at more than two places, and (3) it will not work with a toilet flushing tank.

It is entirely satisfactory to locate the pump jack and pump on a block of concrete in the well pit of a drilled well, provided the pit is properly drained. This saves the cost of a frost-proof drop length and insures against freezing.

With an ordinary automatic system where the motor runs at frequent intervals, the heat in the motor is sufficient to keep it dried out internally and externally so that no damage will result from moisture in the pit, provided no free water gets on or into the motor. If it is desired to place the pump on the ground level, it is necessary to use a frost-proof drop if the system is to be automatic. Under these conditions a small pump house should be constructed over the pump head and motor. It is advisable to have a separate circuit to the pump from the main service switch at the house or barn; otherwise the light may flicker sufficiently to be annoying when the pump is running.

The main pipe line connecting the pump with the pressure tank or gravity tank should be one inch in diameter or larger. A one-inch main line between the pump and the pressure tank is satisfactory if the tank is not over 10 or 15 feet from the pump and the pump capacity does not exceed 250 gallons per hour. For larger systems, or where the tank is located a considerable distance from the pump, larger pipe is necessary. The main pipe should be large enough so that the loss of head in pounds of pressure will not be more than one-half pound. Additional allowance should be made for ells. One ell will offer as much resistance to the flow of water as eight or more feet of pipe. One-inch water mains, extending from the supply tank to the barn, houses and other outbuildings, will be large enough for most conditions.

Water being indispensable, some provision should be made where electric power is used for pumping in case of emergencies. The following methods are suggested: (1) Operate the pump with a gas engine or tractor; (2) connect a hand pump on windmill to the pump rod, and (3) remove the entire electric pumping head and attach a hand pump.

A new well for domestic water supply should be located three of four feet from the house, with the well pit connecting with the basement. This arrangement keeps the system from freezing and makes it readily accessible. The construction of the pit is similar to the others discussed before.

Soft water can be obtained by collecting rainwater from the roofs of buildings or by the use of a water softener. On most farms the cistern is the more common source of soft water.

The ideal system for pumping cistern water consists of a small automatically operated electric pump of the hydropneumatic type. This system is easy and simple to install and satisfactory in operation. All that is necessary is to run a pipe from the pump into the cistern and another pipe to the faucets where water is desired. Where both hard and soft-water systems are installed it is desirable to connect the two systems.

The water softener has the following advantages: (1) It provides an unlimited supply of soft water; (2) the water is as clean, pure and odorless as the well water; (3) the cost of a good softener is but very little greater than the cost of an automatic electric cistern pump and less than the combined cost of a cistern and pump, and (4) the common salt required to keep the softener in condition will cost but little if any more than electricity required to operate the pump.

In the selection of equipment the character and reputation of the manufacturer, and the installation and service provided by the dealer is important. Water is indispensable, and occasionally repairs will be needed, so that it is important in selecting equipment that this be kept in mind. It is generally good policy to purchase standard types of equipment and avoid experimenting with new and untried types or freak systems for which exorbitant and excessive claims may be made.

Central Power-Farming Stations Serve Peasant Farmers of Russia

SO-CALLED intervillage machinery-tractor stations have been established in the U.S.S.R. (Russia) for large-scale mechanized farming of peasants' lands, reports the Bureau of Agricultural Economics, U. S. Department of Agriculture.

The station is a central machinery and power base, serving large number of small peasant land holders. It is equipped with tractors and other modern agricultural machinery, all standardized, and has well-equipped repair shops. It contracts with peasants to do all the field work that can be mechanized, including threshing, for a share of the crop. The peasants supply the labor, and where special skill is needed, as in the case of tractor operators, special training is provided by the station, which also supplies all technical supervision and assistance and is responsible for repair work. Contracts made by the station usually embrace all or most of the land belonging to a particular village which is worked as a unit.

The first station was organized in Ukraine in 1927, by the agronomist Merkevich, the author of the plan and leader of the movement. This station has 140 tractors and serves 26 villages with an area of about 60,000 acres. Plans for 1929-30 call for the organization of 102 stations, 50 per cent of which will be in Ukraine and north Caucasus. The maximum area contemplated to be served by any one station is 140,000 to 150,000 acres.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Nebraska Tractor Tests, 1920-1928 (Nebraska Station (Lincoln) Bulletin 233 (1929), pp. 37, figs. 5).—This bulletin summarizes all reports of Nebraska official tractor tests conducted since the work began in 1920 under the provisions of the Nebraska tractor law. During the nine years that this work has been in effect tests have been conducted on 154 different models and types of tractors. During the first four seasons of testing there were several tractors the claims of which had to be revised before they could complete the test. During the last five years, however, every tractor tested has been able to go through the test and meet all original claims made for it.

At the beginning of the tractor testing season of 1928 a new procedure was incorporated in the method of testing tractors as follows: After the limber-up run of 12 hours is completed, the tractor is given a series of brake horsepower tests, the first being a 2-hour test with the engine developing maximum horsepower at rated engine speed.

Upon completion of the 2-hour maximum test, a series of experimental runs of 20 minutes' duration is made. Starting with the 100 per cent maximum, all adjustments are made to bring about maximum horsepower at the rated engine speed. The load on the dynamometer scales is next reduced one per horsepower at rated engine speed and a run of 20 minutes is made. After completing this rated load run at maximum carburetor settings, the adjustments are all changed back to the 100 per cent maximum test and former readings verified. The load on the dynamometer scales is next reduced one per cent and the carburetor adjusted to a leaner mixture until this load is carried at rated engine speed. A run is then made at rated load with the above-mentioned carburetor setting. The same procedure is carried out for 98, 97, 96 per cent, and so on, ultimate maximum.

After the completion of the preliminary run the manufacturer is asked to select the particular carburetor setting that he desires to be used in the official tests. All official tests are then made on the setting chosen by him.

The data show "quite clearly the possibilities and advantages of a carburetor designed to operate economically over a wide range of loads without changing its adjustment. A tractor equipped with this carburetor would show good economy under field conditions where the load varies through quite a wide range."

The results also indicate that the manifolding must be very carefully worked out and should be verified by actual tests before final adoption. "The beneficial results of a good carburetor may be almost lost if it is used in conjunction with a poor manifold. Some manufacturers are fully aware of this problem and are giving it due consideration."

Housing Farm Poultry. W. A. Foster and H. H. Alp (Illinois Station (Urbana) Circular 337 (1929), pp. 24, figs. 24).—Practical information is given on the planning and construction of farm poultry houses, together with working drawings of recommended structures.

The Failure of Plain and Spirally Reinforced Concrete in Compression, F. E. Richart, A. Brandtzaeg, and R. L. Brown (Illinois University, Engineering Experiment Station (Urbana) Bulletin 190 (1929), pp. 74, figs. 23).—This extensive set of studies indicates that the behavior of plain concrete in simple compression may be considered for three stages of loading, each having certain special characteristics. In the first stage the material acts like an elastic material, stresses and strains being proportional. The second stage is marked by appreciable deviations, particularly of the lateral strains, from the linear stress-strain curves of the first stage, and a steady increase in the ratio of lateral to longitudinal strains. The beginning of the third stage is marked by an abrupt increase in the ratio of lateral to longitudinal strains; as a consequence the volume of the material, which had been decreasing under increasing loads, changes its behavior radically and increases with further loading.

The action of spirally reinforced columns at the early stages of loading is essentially the same as that described for the first and second stages of loading of plain columns. During the second stage plastic deformation of the material begins and the lateral deformations become large enough to produce a small stress in the spiral, which in turn exerts a slight lateral pressure on the concrete core. The third stage, which has been denoted as the "spiral range" of action, begins at a load corresponding to that at which the splitting of plain concrete begins.

Reinforced Brickwork, M. Vaugh (Missouri University, Engineering Experiment Station (Columbia) Bulletin 28 (1928), pp. 84, figs. 68).—The results of a series of experiments are reported and discussed, indicating that slabs and beams of reinforced brickwork are technically practicable under American building conditions. Such slabs and beams react in a manner practically indentical with the reactions of reinforced concrete, due allowance being made for properly proportional stresses in concrete and steel.

The modulus of elasticity of brickwork made with cement-sand mortar and brick is assumed as 2,000,000 pounds per square inch for ordinary calculations. Under the conditions of the experiment, stresses of 650 pounds per square inch in compression on the brickwork are considered safe and probably unnecessarily conservative.

It is found that shearing stresses in beams are not so well resisted by brickwork as by concrete, and that while small beams may be made safe without stirrups, no important beam should be made without at least light stirrups. Stirrups in general should be heavier than called for by standard concrete practice, and it seems very important that some top reinforcing be supplied near the ends of beams by placing small rods in the top mortar joint or by bending up one or more rods. Slabs made of not more than one course of brick seem to have no difficulty in resisting the shear likely to come on them if the slab is otherwise properly designed.

Careful and accurate control of the moisture content of the brick was found to be very important. Brick with too high absorptive powers will injure the mortar by removing too much water. Brick completely saturated or glazed to prevent absorption are hard to lay, do not develop the full adhesion of the mortar, and do not take full advantage of the water-cement ratio law.

Air Infiltration Through Various Types of Brick Wall Construction, G. L. Larson, C. Braatz, and D. W. Nelson (Journal of the American Society of Heating and Ventilating Engineers (New York) 35 (1929), No. 3, pp. 125-136, figs. 6).—The results of a study by the University of Wisconsin and the American Society of Heating and Ventilating Engineers are reported, which dealt with five 13-inch brick walls of different character as regards nature of brick, mortar and workmanship.

The test apparatus consists essentially of a pressure chamber and collecting chamber, between which the test wall is secured, and air-tight seals are made between the two sides of the wall. Artificial wind pressure is produced by a small motor-driven blower, communicating with the pressure chamber through an adjustable damper which controls the pressure drop through the wall.

Two types of brick were used, one hard face and the other more porous, and three walls were built with cement-lime mortar and the other two with lime mortar. Each wall was subjected to a wind pressure corresponding to a range of wind velocities of from 5 to 30 miles per hour.

The results apparently revealed no correlation between the amount of infiltration and the aging of the test walls or between the humidity at the time of the tests and the variation in infiltration.

A greater variation in infiltration was observed between the good and the poor walls built of porous brick than between those built of hard brick. The conclusion is drawn that the same grade of workmanship results in more leakage through cement-lime mortar joints on porous brick than on hard brick. "This would indicate then that to secure the same infiltration through mortar in a porous brick wall as in a hard brick wall additional care in workmanship would be required to the extent of soaking the bricks before laying."

Fire Resistance of Hollow Load-Bearing Wall Tile, S. H. Ingberg and H. D. Foster ([U. S.] Bureau of Standards Journal Research, 2 (1929), No. 1, pp. 334, pls. 41, figs. 146).—The results of three series of fire tests of all construction built of hollow load-bearing wall tile of representative designs and clay materials are reported.

The first tests were made on wall sections 1 foot wide and 6 feet high that were subjected to fire on one side while under working load, the main object being to determine how the fire exposure effects the individual tile units. This was found to vary with the type of clay used, hardness of burning and design of the unit, from minor cracking of a few of the units in the specimen to failure under load a little after two hours.

The second group of tests was with wall specimens 4 feet wide and 4 feet high exposed to fire on one side, under load or restrained within the containing frames, and were made to study the effect of changes in design of the unit, and in the constituents and preparation of the clay.

The addition up to 2 per cent of ground burned clay to the raw clay was found to be without effect, but higher percent-

ages increased the fire damage, apparently because of initial shrinkage cracks radiating from the grog particles. Additions up to 15 per cent by volume of sawdust to the raw clay decreased the tendency to cracking when exposed to fire without seriously decreasing the normal strength of the tile. Finer grinding and a greater amount of pugging of the raw clay increased the strength of the tile and consequently its load-carrying ability when exposed to fire.

Of modifications in the design of the unit, one with double outside shells improved the fire resistance for all but very dense tile in confining the cracking mainly to an outer thin shell. Increased shell thickness was also found to decrease the fire effects, as also fillets of up to ¼-inch radius at the junctions of shells and webs.

The final series consisted of 167 fire-endurance tests and four fire and water tests of typical wall constructions, 71 of which were made with walls between 10 and 11 feet high and 8 to 16 feet wide. The thickness ranged from 8 to 16 inches, and plaster, stucco or brick facing was applied on a number of the walls. The walls were subjected to constant applied loads of 70 to 120 pounds per square inch during the fire test, were restrained within the containing frames, or were tested unrestrained, the latter condition being representative of walls in low buildings or the upper-story walls of higher buildings. The results are summarized as fire-resistance periods, which are determined by the time the walls sustained load under fire exposure and prevented the average temperature rise on the unexposed side from exceeding 139 degrees (Centigrade) (250 degrees Fahrenheit) or the maximum rise at any point where temperature measurements are taken from exceeding 180.6 degrees (325 degrees Fahrenheit).

Reclamation of Peat Land in Northern Europe, W. G. Ogg, (Scotland Journal of Agriculture (Edinburgh). 12 (1929), No. 1, pp. 5-20, pls. 2).—A brief description of some of the peat lands in northern Europe is given and examples of reclamation are cited in northwest Prussia, Bavaria and Denmark. The reclamation and development work includes drainage and cultivation by special machinery.

In the latter connection a new cultivation machine has been devised in Germany for the first cultivation of peat soils. It is a motor-driven machine like a tractor with wide wheels, and an attachment behind containing a long shaft with knives or tines. When this is put into gear it revolves at a rapid rate and is then lowered to the surface of the peat, which is churned into small pieces. It is usual to cultivate twice with this machine, first to a depth of 8 inches, and the second time to a depth of about 15 inches. The surface of the peat is thoroughly broken up and aerated at a much less cost than by any other means, and one machine can cultivate from 8 to 12 acres (single cultivation) per day.

The regular use of these machines for subsequent tillage is not advisable, since they are apt to allow the land to become infested with weeds and they produce too fine a tilth, making the surface impermeable to rain water.

Experiments to Determine Rate of Evaporation from Saturated Soils and Riverbed Sands, R. L. Parshall (American Society of Civil Engineers (New York), Proceedings 55 (1929), No. 4, pt. 1, pp. 843-854, figs. 4).—In a contribution from the Colorado Experiment Station a description is given of studies of the evaporation loss from soils contained in tanks under like exposure, the soils ranging from coarse river sand to heavy dark alkaline soil, with the water-table maintained at 1, 6, and 12 inches beneath the surface. It is not the intention to present conclusive data as to the loss by evaporation from moist soil surfaces, but rather to describe the methods and procedure followed and submit such information as is now available as an indication of the general trend of the relations existing between the various soils and conditions as well as supporting the general conclusions drawn.

Covers were provided to protect the tanks against rain, but nearly each week more or less rain fell on the exposed soil surfaces. Experience with these tanks shows that a marked reduction in the evaporation loss occurs when the covers are in place. The cooling effect of the rain on the soil increases the surface tension of the capillary moisture drawn up from the water-table. Rain water falling on the soil also dilutes the soil solution and if the solution is alkaline it increases the rate of evaporation. It is evident that, although adding moisture to the soil at the time, light showers may later cause a more rapid depletion of the moisture already within the soil.

With reference to the trend of evaporation loss from different soils with increasing depth of water table, it was found that the four river samples of fine sand with the water-table at one inch, show a loss equal to that from a free water surface. The loam and heavy adobe soils show a loss of 83 and 75 per cent, respectively, for a depth of one inch to the water-table, as compared with that from free water. When the water-table is 6 inches below the soil surface, the Rocky Ford sand and the adobe soil show a reduction of loss, while the loam soil and both the medium and coarse river sands show a loss equalling that from the free water surface.

"It is believed that the method of using the Mariotte principle in obtaining the evaporation loss from moist soils, even though there are some apparent inconsistencies in its operation, gives more dependable results than the method of weighing. The results . . . show very marked consistency for fine river sands, which are essentially indentical, with the exception of the silt content. Those cited are in evidence of the dependability of the apparatus. The feature of automatic control is highly desirable."

Terracing for Moisture Conservation, H. H. Finnell ([Oklahoma] Panhandle Station (Goodwell) Panhandle Bulletin 2 (1929). pp. 13-16, fig. 1).—The results of experiments on the use of terracing for soil moisture conservation are briefly presented and discussed.

A study of what becomes of rainfall on the heavy type of soil at Goodwell showed that an average of only 3.58 inches of the 17.3 inches received annually soaks into the soil and becomes a part of the permanent body of soil moisture. About 5.41 inches of rain comes in such small showers that it does not add anything to subsoil moisture, remaining in the surface mulch, and being entirely evaporated after a few days. The rest of the rainfall, 11.89 inches, may be classified as moderate to excessive and does varying amounts of good as to the building up of soil moisture supplies.

A preliminary consideration of the run-off problem reveals the fact that run-off conditions vary sharply even in different parts of the same field. Very slight inequalities of slope bring about the accumulation of useless surplus water in certain low spots and the injurious lack of moisture in the best drained portions of the field.

Terracing was found to greatly improve the distribution of the moisture, and the cropping results were strongly in favor of terracing.

Knock Ratings of Pure Hydrocarbons, A. W. Nash and D. A. Howes (Nature [London], 123 (1929), No. 3095, pp. 276, 277). —Experiments conducted at the University of Birmingham, England, on the antiknock properties in an internal combustion engine of pure samples of eight hydrocarbons mixed with unsaturated materials are reported. These were used in 20 per cent concentrations.

The results showed that cyclohexene has antiknock properties equivalent to benzene, while the others are far more effective than benzene, especially diamylene and diisobutylene, which at a concentration of 20 per cent are found to be equivalent to 37.5 per cent and 40 per cent benzol, respectively. Tested on the same scale, 20 per cent of toluene was found to be equivalent to 22.5 per cent of benzol. Thus aromatic hydrocarbons have lower knock rating than the unsaturated materials.

Of the olefines tested, those which are the more stable toward bromine, sulfuric acid, potassium permanganate, and potassium bichromate, are the more effective in suppressing knocking.

Book Review

"The Development and Costs of the Oxford Process for the Production of Sugar from Sugar Beet" is Bulletin No. 4 of the Institute for Research in Agricultural Engineering, University of Oxford. It brings up-to-date information on the development of and results obtained by the Oxford process for the dessication of beets and the subsequent extraction of sugar from them. Conclusions indicate that the process, which lowers manufacturing costs, may be the salvation of the English sugar industry when its present government subsidy ends in 1934. The Oxford University Press, 114 Fifth Avenue, New York, N. Y. sells the bulletin in America at eighty-five cents per copy.

"Farm Machinery and Equipment," by H. P. Smith is a new text for the instruction of college agricultural and agricultural engineering classes in farm machinery. Farm equipment salesmen and dealers, agricultural extension workers, and farmers will also find it a useful reference. The eleven parts of the book cover "Principles of Farm Machinery," "Soil Preparation Machinery," "Seedbed Preparation Machinery," "Seeding Machinery," "Cultivating Machinery," "Harvesting Machinery," "Seed Separation Machinery," "Seed Preparation Machinery," "Fertilizing Machinery," "Transportation Equipment," and "Cleaning and Grading Machinery." Its 448 pages bear 554 illustrations. It is one of the McGraw-Hill publications in agricultural engineering, edited by Dan Scoates. List price is $4.00.

"Electricity in Agriculture," by C. A. Cameron Brown is published as Bulletin No. 5 of the Institute for Research in Agricultural Engineering, University of Oxford. Of its two parts, part I reports an investigation undertaken by the Institute and part II is on general considerations on the subject. In the results tabular data are given on power consumption, date of work, cost, and power input for various operations. Some interesting charts on load and power consumption characteristics are included. The general considerations cover such subjects as average rural conditions, density and distribution of population, electrical construction required, length of line, loads for various classes of farms and villages, cost and rates. The 75 pages are available for 85 cents from the Oxford University Press, 114 Fifth Avenue, New York, N. Y.

AGRICULTURAL ENGINEERING

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

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RAYMOND OLNEY, Editor

R. A. Palmer, Assistant Editor

Stimuli

"THE labor-saving appeals, while not yet exhausted, cannot always remain the principal stimuli in engineering design." This statement by H. B. Walker in his paper before the World Engineering Congress (published in this issue) is as worthy of consideration by agricultural engineers as by the leading engineers of the world assembled at Tokio. When we come to the end of our rope in labor-saving, what next? Or, in addition to labor-saving, what are our other opportunities?

Mr. Walker goes on to say that "One part of the problem is to supply a suitable power plant and the second is to effectively apply this power to crop production." In other words, the next step from the design and application of machinery as a substitute for labor will be a revision of agricultural practice and a reorganization of agriculture along lines which are also land-saving, capital-saving and management-saving.

In the past, labor has been such a prominent factor in agricultural production costs that almost any machine or practice which saved labor increased overall efficiency. However, every new machine tends to increase the relative importance of capital as a factor in production costs. Increases in land value and improved tillage practices affect the importance of land in a similar manner. Reorganization of agriculture into larger units and improved management practices increase the importance of management. These factors all warrant and are beginning to receive the attention of agricultural engineers. They are new economic stimuli.

What about social stimuli for agricultural engineering activities? As Arthur Huntington puts the question in a recent article in this journal (Vol. 10, No. 8, August, 1929) "Shall we continue to think in terms of efficiency of production or shall we turn our attention to the well-being of those in engaged in the industry of agriculture?

When we consider that the whole economic organization of society is simply a means to an end, namely the well-being of people, we see that we are, as agricultural engineers, motivated by social stimuli. In fact we have proudly pointed to the social significance of our labor-saving machinery. We have lightened the farmer's labors, made them more agreeable, and have given him more time and means for enjoying the better things of life. These benefits have been largely incidental to labor-saving developments.

But all social effects of engineering developments are not necessarily beneficial. To prevent or alleviate any bad social effects to their work is one of the problems engineers must meet. Agricultural engineers are in part responsible for agricultural surpluses, for increased competition between commodities and between producing areas. Our labor-saving devices and practices have encouraged farmers to stay on the farm; and at the same time have made it necessary for more of them to go to towns and cities for employment.

Some of the conditions we have helped to bring about need changing. Could we want a stronger stimulus to increased activity?

Education Needed

EVERYONE is watching with interest and no sensible person is envying the new Federal Farm Board its mission of agricultural relief.

As stated in a recent issue of the National City Bank Bulletin, "Competition is irrepressible wherever industrial progress is being made and new methods are a large factor in the present farming situation."

Briefly, the job of the farm board is to painlessly repress this irrepressible competition, or to provide for expansion of markets so that all can dispose of their products at satisfactory prices.

Economic pressure on sub-marginal farmers is the source of pain that has been called the farm problem. Can the farm board foresee and bring about necessary readjustments by less painful means? The more efficient marketing which is sought through cooperation and stabilization will be a step in progress, to be sure, but it will not have any extensive or lasting effect on the supply-demand ratio. Efforts to develop by-products and otherwise expand markets will be effective to the extent that they are successful.

Education, however, will no doubt ultimately prove to be the biggest factor in preserving the economic balance of agriculture. It is only in comparatively recent times that the farmer has developed from a self-sufficient agrarian into a business man. Many farmers have not yet learned the economic signficance of their production and marketing activities and those of other farmers. They need to know more of the economics of production and consumption, of supply and demand, of prosperity. With this understanding they will see the need of responding to, rather than resisting, economic pressure; they will seek new pastures when the old become overcrowded. Understanding leads to adaptation; ignorance, to resistance. Without more understanding of his economic position no superimposed system or marketing machinery can make the farmer more prosperous and contented.

More Industrialization

THE industrialization of agriculture goes merrily on, even in the midst of the depression from which many farmers are still hoping for political relief.

New evidence is the classified newspaper ad of a farm manager looking for an opportunity to manage 1,000 acres or more on a livestock basis applying quantity production and other modern industrial principles.

A few years ago such ads were not seen. If they had been published, they would not have been worth the cost of insertion. But the ad referred to will undoubtedly get the manager the opportunity he is looking for. There are now more farms of 1,000 acres or larger; the necessary machinery is available; the methods to be used have been tried and proven; this particular man can show book records of profits ranging from 20 to 49 per cent of working capital, after charging off 8½ per cent for the value of the land, for each of the past 4 years.

Who's Who in Agricultural Engineering

E. G. McKibben

W. W. Magee

B. D. Moses

J. F. Max Patitz

E G. McKibben

Eugene George McKibben (Mem. A.S.A.E.) is associate professor of agricultural engineering in charge of farm machinery instruction at Iowa State College. His training at Iowa State College, begun in 1916, was interrupted by the war, but was completed in 1922, when he received his bachelor's degree in agricultural engineering. The University of California immediately employed him as assistant in the division of agricultural engineering. When he resigned in 1928 to accept his present position he was assistant professor, and assistant agricultural engineer of the California Agricultural Experiment Station. During his stay at Davis he also earned his master's degree in agricultural engineering, awarded him in 1927. He is a leading authority among agricultural engineers on the kinematics and dynamics of farm machinery. The twenty or more articles by him published in AGRICULTURAL ENGINEERING include his series on "The Kinematics and Dynamics of the Wheel-Type Farm Tractor." He is also inventor of a dynamometer for testing the power capacity of a man, an ingenious device for demonstrating to students and farmers the limitations and inefficiency of the human body as a power producer.

W. W. Magee

Wayland Wells Magee (Assoc. Mem. A.S.A.E.) is manager of Summer Hill Farm, a 5000-acre tract near Omaha, Nebraska, which has been farmed by the same family for more than fifty years, specializing in the production of pure-bred livestock and certified field seeds. He received his bachelor's degree at the University of Chicago in 1905, went to Germany to take graduate work in botany at Bonn and later studied agriculture at the University of Nebraska and Iowa State College. He also studied law and was admitted to the bar of Illinois in 1908. Soon after this, however, he took up the management of the Summer Hill Farm. At present he is president of the Nebraska Crop Growers Association; a member of the Nebraska Committee on the Relation of Electricity to Agriculture; and active in the management of the Nebraska Dairy Development Society, Ak-Sar-Ben Livestock Exhibition Company, and the Douglas County Farm Bureau. The Omaha Branch, Federal Reserve Bank of Kansas City, knows him as the farmer representative on its board of directors. Modest, he says, "The only thing I have done for the good of the order is to farm the best I knew how for twenty years."

B. D. Moses

Ben Duncan Moses (Mem. A.S.A.E.) is associate professor of agricultural engineering at the University of California, associate agricultural engineer at the California Agricultural Experiment Station, and director and secretary of the California Committee on the Relation of Electricity to Agriculture. Since receiving his bachelor's degree in 1909 from the college of mechanics, University of California, his experience has included two years in the assembly department of the Holt Manufacturing Company; a summer of tractor plow operation in Canada; a year of teaching sciences at New Mexico Normal School; four years as assistant in mechanics, University of California, teaching hydraulics and kinematics; and six years with the Yuba Manufacturing Company (tractors) in sales and service management work. In 1922 he accepted his present position as assistant professor of agricultural engineering at the University of California. When the California Committee on the Relation of Electricity to Agriculture was formed in 1924 he was chosen as its secretary and has since been a leading figure in the rural electric progress in California, a state which has lead other states in this development.

J. F. Max Patitz

Johann Friedich Max Patitz (Mem. A.S.A.E.) is chief-consulting engineer of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin. He went to high school in Dresden, Germany, until his parents emigrated to the United States. In 1885 he entered the employ of the E. P. Allis Company, the predecessor to the Allis-Chalmers Manufacturing Company, working as errand boy, blue printer, draftsman, designer, and chief draftsman, mainly on steam engines and steam turbines and their accessories, blowing engines and air compressors. After formation of the Allis-Chalmers Manufacturing Company he was appointed chief consulting engineer, working in connection with all the departments of this company in mechanical matters. In 1914 the Allis-Chalmers Manufacturing Company started building power machinery for agricultural purposes, and he was put in charge of the engineering of it, in addition to his other duties. Recently he has given up the direct charge of the engineering of the tractor division and works with this department in a consulting capacity only, the same as with other departments of the company. He has been a member of this Society since 1914.

A. S. A. E. and Related Activities

PROGRAM

Meeting of the
Power and Machinery Division
American Society of Agricultural Engineers
Hotel Sherman, Chicago, December 2 and 3, 1929

Forenoon — 9:30 a.m. — Monday, December 2

1. "Experiences in Industrialized Wheat Production"— John S. Bird, president, The Wheat Farming Co.
2. "Trends in Large-Scale Wheat Production" — Hickman Price, Texas wheat grower
3. "Fundamental Factors Which Determine the Effective Capacity of Large Field Machines" — E. G. McKibben, associate professor of agricultural engineering, Iowa State College

Afternoon — 2:00 p.m. — Monday, December 2

1. General-Purpose Farm Tractor Symposium
   (a) "Corn Planting and Cultivating With the General-Purpose Tractor" — J. Leo Ahart, manager and agricultural engineer, Boni Agri Farms (Iowa)
   (b) "Cultivating Equipment for the General-Purpose Tractor" — Theo. Brown, manager, experimental department, Deere & Co.
   (c) "Spraying Equipment for the General-Purpose Tractor" — Wm. Abildgaard, John Bean Mfg. Co.
   (d) "Organization of Research in the Adaptation of the General-Purpose Tractor" — R. W. Trullinger, agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture
   (e) "New Developments in Wheel Design for the General-Purpose Tractor" — R. J. Altgelt, designer, Oliver Farm Equipment Co.
   (f) "The General-Purpose Tractor in Potato Production" — H. B. Josephson, research engineer, Pennsylvania State College
   (g) "Designing Hay Machinery for the General-Purpose Tractor" — R. H. Driftmier, Kansas State Agricultural College
2. General Discussion

Evening — 7:30 p.m. — Monday, December 2

1. Committee Reports
   (a) Committee on Dairy Engineering — A. W. Farrall, chairman
   (b) Committee on Grain Drying — W. M. Hurst, chairman
   (c) Committee on Weed Control — A. J. Schwantes, chairman
   (d) Committee on Fertilizer Placement — E. R. Gross, chairman
   (e) Committee on Hay and Forage Crop Drying — H. B. Josephson, chairman
   (f) Committee on Combine Development — E. M. Mervine, chairman
   (g) Committee on Row Crop Management — G. W. McCuen, chairman

Tractor and Thresher Meeting

THE tractor and thresher division of the National Association of Farm Equipment Manufacturers will hold a one-day meeting, December 4, at the Auditorium Hotel in Chicago.

George W. Iverson, agricultural engineer, Caterpillar Tractor Company, is scheduled to speak on the timely subject of "Economic Loads for the Tractor." Five other subjects definitely on the program are Russian Development, Uses of the Combine and its Attachments, Use of the Combine in Harvesting Soybeans, The Trade-in Problem, and Threshing Machine Simplification and Standardization. Plans are being made for the discussion of additional subjects which are highly important at present to tractor and thresher manufacturers.

Agricultural engineers interested primarily in farm power and machinery are invited and urged to stay over for this meeting after attending the Farm Power and Machinery Division meeting of the American Society of Agricultural Engineers on December 2 and 3. The meetings have been scheduled on successive days for the convenience of those who will want to attend both.

Forenoon — 9:30 a.m. — Tuesday, December 3

1. "The Future of Wrought Iron for Farm Equipment Fabrication" — Dr. James Aston, consulting metallurgist, A. M. Byers Company
2. "Future Requirements of Potato Machinery" — Dr. E. L. Nixon, Pennsylvania State College
3. "Need for Further Standardization of the Power Take-Off" — W. L. Zink, engineer, General Implement Company

Afternoon — 2:00 p.m. — Tuesday, December 3

1. "Composite and Solid Steels for Tillage Implements"— F. F. McIntosh, Crucible Steel Company of America
2. "The Farm Transportation Problem" — C. M. Eason, supervisor, equipment and sales engineering, General Motors Truck Co.
3. "Relation of Farm Machinery to Maintenance of Soil Fertility" — C. A. Bacon, research engineer, Oliver Farm Equipment Co.
4. "Weed Control in the Spring Wheat Area" — J. G. Haney, International Harvester Co.
5. Business Session

PROGRAM

Meeting of the
Structures Division
American Society of Agricultural Engineers
Hotel Sherman, Chicago, December 3 and 4, 1929

Forenoon — 9:30 a.m. — Tuesday, December 3

1. "National Problems in Farm Home Making"— Mrs. Chas. M. Sewell, director, home and community work, American Farm Bureau Federation
2. "The Home Modernizing Bureau and the Farm Home"— H. S. Sackett, director, Home Modernizing Bureau. Discussion led by K. J. T. Ekblaw, consulting agricultural engineer, Chicago
3. "The College Policy in Farm Home Development"— Deane G. Carter, professor of agricultural engineering, University of Arkansas
   Discussion led by M. C. Betts, architect, U. S. Department of Agriculture

Afternoon — 2:00 p.m. — Tuesday, December 3

1. "More Farm Storage for Wheat" — H. M. Bainer, director, Southwest Wheat Improvement Association
2. "Recent Investigations in Grain Storage" — F. C. Fenton, chief, agricultural engineering department, Kansas State Agricultural College
3. "Floor Heating as a Factor in Animal Housing" — B. M. Stahl, agricultural engineer, Ohio State University

Forenoon — 9:30 a.m. — Wednesday, December 4

1. "Report on Dairy Barn Questionnaire Project" — W. G. Ward, agricultural engineer, Iowa State College
2. "The Standard Milk Control Code" — Dr. C. A. Abele, director, bureau of inspection, Alabama State Board of Health

Joint Session with Rural Electric Division — 11:00 a.m.

3. "The Use of Electric Power for Ventilating Stables" — J. L. Strahan, agricultural engineer, Louden Machinery Co.

Afternoon — 2:00 p.m. — Wednesday, December 4

1. "The Farm Building Research Situation" — Henry Giese, senior agricultural engineer, U. S. Department of Agriculture
   General discussion by individuals and representatives of organizations interested in the development of modern farm buildings
2. Business Session

PROGRAM

Meeting of the
Rural Electric Division
American Society of Agricultural Engineers
Hotel Sherman, Chicago, December 4 and 5, 1929

Forenoon — 9:30 a.m. — Wednesday, December 4

1. "Value of High Grade Milk" — W. D. Dotterrer, director of laboratories, Bowman Dairy (Chicago)
2. "The Place of Electric Power in the Production of High Grade Milk"—
   H. W. Allyn, superintendent, Rock River Farms (Illinois)

3. "Recent Developments in Small Dairy Equipment for Electric Power Application"—
   A. W. Farrall, development engineer, Douthitt Engineering Co.
   J. H. Godfrey, director of research, Creamery Package Mfg. Co.

Joint Session with Structures Division — 11:00 a.m.

4. "The Use of Electric Power for Ventilating Stables"—J. L. Strahan, agricultural engineer, Louden Machinery Co.

Afternoon — 2:00 p.m. — Wednesday, December 4

1. "Experiences with Dairy Equipment in Rural Electric Service Work"—
   E. R. Meacham, manager, rural service dept., Wisconsin Power & Light Co.
   Richard Boonstra, agricultural engineer, Public Service Co., of Northern Illinois
   H. S. Hinrichs, rural service engineer, Kansas Power & Light Co.
   E. C. Easter, agricultural engineer, Alabama Power Co.
   C. P. Wagner, rural service engineer, Northern States Power Co.
2. "Electrical Refrigeration of Poultry Products" — Wm. H. Lapp, director Poultry Research Society of America
3. "Developments in Electric Incubation and Brooding"—
   J. C. Scott, agriculturist, Puget Sound Power & Light Co.
   H. J. Gallagher, rural electric engineer, Michigan State College
   T. E. Hienton, project leader in rural electrification, Purdue University
   G. W. Kable, director, National Rura. Electric Project

Forenoon — 9:30 a.m. — Thursday, December 5

1. "Value of Processing Livestock Feeds"—
   C. W. McCampbell, professor of animal husbandry, Kansas State Agricultural College
   J. H. Hilton, assistant professor of dairy husbandry, Purdue University
   L. E. Card, professor of poultry husbandry, University of Illinois
2. "Experience in Feed Grinding for Large-Scale Beef Production"—Harry Hopley, Iowa farmer
3. "Economic Limit of Small Grinding Plants for Electric-Motor Drive"—
   F. J. Zink, agricultural engineer, Westinghouse Electric & Mfg. Co.
4. "A Small Electric-Power Grinding and Mixing Plant"—J. E. Nicholas, research engineer, Pennsylvania State College

Afternoon — 2:00 p.m. — Thursday, December 5

1. "Results of Tests of Small Electric-Drive Grinders"—
   F. W. Duffee, associate professor of agricultural engineering, University of Wisconsin
   E. B. Lewis, agricultural engineer, University of Nebraska
2. "Underground Wiring for Farm Electrical Installations"—H. H. Weber, engineer, Rome Wire Co.
3. "Results of Experiments with an Electric Hotbed" — R. R. Parks, agricultural engineer, University of Missouri
4. "Developments on the Rural Electrification Projects"—Discussion by project leaders, led by G. W. Kable, director, National Rural Electric Project
5. Business Session

TENTATIVE PROGRAM

Meeting of the
Land Reclamation Division
American Society of Agricultural Engineers

Kansas City, Missouri, December 30 and 31, 1929

Forenoon and Afternoon — Monday, December 30

9:30 a.m. and 2:00 p.m. Simultaneous Sessions on

1. Soil Erosion Control
M. R. Bentley, presiding

"Soil Erosion Control Work on the Guthrie (Okla.) Project"—C. E. Ramser, senior drainage engineer, U. S. Department of Agriculture
"Latest Developments in Terracing to Prevent Soil Erosion"—C K. Shedd, extension agricultural engineer, University of Missouri, and J. T. Copeland, extension agricultural engineer, Mississsippi A. & M. College
"Extension Work in Soil Erosion Control"—G. E. Martin, agricultural engineering specialist, Oklahoma A. & M. College
"The Nichols System of Terracing"—M. L. Nichols, professor of agricultural engineering, Alabama Polytechnic Institute
"The Engineer's Contribution to Soil Erosion Control"—Clarence Roberts, editor, "Oklahoma Farmer-Stockman"
"A Proposed Program of Work for the A.S.A.E. Committee on Soil Erosion"—M. R. Bentley, chairman
Round Table Discussions of Soil Erosion Control Problems

2. Drainage
C. E. Seitz, presiding

"The Solution of an International Drainage and Flood Control Problem"—E. V. Willard, commissioner of drainage and waters, State of Minnesota
"Rehabilitation of Drainage and Levee Districts"—Clark E. Jacoby, president, Clark E. Jacoby Engineering Co. (Tentative)
"Influence of Drainage on Forest Growth"—P. C. McGrew, assistant drainage engineer, U. S. Department of Agriculture (Tentative)
Round Table Discussions of Drainage Problems

3. Irrigation
M. R. Lewis, presiding
(Program being arranged.)

4. Land Clearing
(Program being arranged.)

Forenoon — Tuesday, December 31

9:30 a.m. General Session
Ivan D. Wood, chairman, A.S.A.E. Land Reclamation Division presiding

"The Engineering Factor in Land Reclamation"—W. G. Kaiser, president, American Society of Agricultural Engineers
"The Cost of Droughts on the Great Plains"—Joseph B. Thoburn, curator, Oklahoma Historical Society
"The Present Status of Extension Work in Land Reclamation"—L. A. Jones, senior drainage engineer, U. S. Department of Agriculture
"Economic Justification for Reclamation Activities"—Dr. Elwood Mead, commissioner, Bureau of Reclamation, U. S. Department of the Interior

Afternoon — Tuesday, December 31

2:00 p.m. **General Session**
"The Use of Supplemental Water"—J. C. Russel, agronomy department, college of agriculture, University of Nebraska
"The Federal Policy of Land Ownership in the Western States"—Hon. H. H. Baldridge, governor of Idaho (Tentative)
"Influence of the Federal Policy of Land Ownership on the Financing of Land Development"—Chas. E. MacLain, Anglo-London-Paris Bank of San Francisco (Tentative)
"Organization in Financing Drainage Districts"—Roy N. Towl, Towl, Nelson & Schwartz, consulting engineers (Tentative)

Purdue Rural Electric Conference

ADDRESSES by Arthur Huntington, first vice-president of the American Society of Agricultural Engineers, and Congressman Fred Purnell, ranking member of the Agricultural Committee, House of Representatives, featured the dinner meeting of the third annual conference on rural electrification at Purdue University, October 10, 1929. This annual conference which is jointly sponsored by the Purdue University Agricultural Experiment Station and the Indiana Electric Light Association was attended by 158 persons, excluding all local attendance. Exhibits of farm electrical equipment were shown by thirty-five manufacturers or their representatives in the new agricultural engineering building where the meetings were held.

The program was of two and a half days duration, the first two being devoted to discussions of general topics affecting rural electrification including results of experimental work and the last half day to merchandising problems encountered by rural service men.

Following an address of welcome at the opening of the morning session of the first day by Director J. H. Skinner, Eugene Holcomb, chairman of the Rural Service Committee of the National Electric Light Association, reviewed the progress that is being made in rural electrification. A topic of considerable interest to those present was then discussed by T. A. Coleman, county agent leader, in which he showed the relationship which the county agent bears to rural electrification. The first morning's session was completed by Arthur Shugart, a farmer of Marion, Indiana, who enthusiastically enumerated the ways in which electric current pays its way on his farm.

The general session of the second morning was addressed by four members of the American Society of Agricultural Engineers, Miriam Rapp, home economics department, Purdue university; Richard Boonstra, Public

Service Company of Northern Illinois; Douglas Dow, Detroit Edison Company; and E. W. Lehmann, University of Illinois. Each of these speakers presented very interesting material in their respective papers, the subjects of which are listed in the following order: "Labor-Saving Equipment in Farm Homes"; "How Demonstrations and Demonstration Farms Aid in Rural Electric Development"; "Planning Adequate Farm Electric Service Through Proper Wiring"; and "Proceeding to Analyze Potential Electric Load on Farms."

Both afternoon sessions were devoted to progress reports on current investigational work which is cooperative between the rural electrification project in the agricultural engineering department and other departments of the Purdue Agricultural Experiment Station.

A report on "The Value of Grinding Oats for Hogs and Steers" was presented by F. G. King of the animal husbandry department, and one on "Ground versus Shredded Corn Stover for Dairy Cattle" by J. H. Hilton of the dairy department. C. W. Carrick of the poultry department discussed the "Status of Electric Illumination and Irradiation in Practical Poultry Production." F. D. Brooks of the same department reported on "Problems Encountered in Electric Brooding." Progress in investigational work on mechanical refrigeration for the dairy farm was reported by E. H. Parfitt, dairy bacteriologist. Experience in "Operating the Thresher or Husker-Shredder with an Electric Motor" was related by R. H. Wileman of the agricultural engineering department.

A number of public utility executives attended the dinner meeting addressed by Messrs. Huntington and Purnell. C. V. Sorenson, president of the Indiana Electric Light Association and chairman of the Rural Service Committee of the Great Lakes Division of the National Electric Light Association, acted as toastmaster at the dinner.

Problems of the rural service man in merchandising electric equipment to the farmer were thoroughly discussed on the last morning by four utility service men; John Flessner, Monroe, Michigan, W. J. Parvis, Kokomo, Indiana, J. R. Campbell, Newtown, Indiana, and Bernard Hines, Marion, Indiana.

Fall Meeting Program of Pacific Coast Section Announced

THE Pacific Coast Section, A.S.A.E., will hold a meeting on dairy equipment in connection with the Pacific Slope Dairy show again this year, according to announcement by Walter W. Weir, secretary of the Section. It is to be held at the Civic Auditorium, Oakland, California, November 18.

When Chairman E. J. Stirniman, agricultural engineer, University of California, calls the meeting to order at 9:30 a.m. on that day, C. L. Roadhouse, president of the Pacific Slope Dairy Show Association, will welcome the group. Papers to follow on the morning program are "Portable Dairy Cooling Units," by H. C. Parker, Parker Ice Machine Company and "Effect of Refrigeration on Cream Held on the Farm," by F. C. Price, project director, Oregon Rural Electric Project. Each paper will be discussed following its presentation.

After an inspection of exhibits and a luncheon period Chairman Stirniman will call the agricultural engineers to order again to hear about "Direct Expansion Freezers" from H. P. Ahrnke, Creamery Package Company; "Research in Dairy Engineering" from R. L. Perry, division of agricultural engineering, University of California; "Sanitary Dairy Buildings," from G. H. Melody, board of health, City of San Francisco; and "Economical Dairy Buildings," from H. L. Belton, division of agricultural engineering, University of California.

Mr. Perry is largely responsible for the development of this program. At the University of California and in the Pacific Coast Section he is ably filling the shoes recently vacated by A. W. Farrall, when he left the sunkist state for the industrial opportunities of Chicago.

World Engineering Congress

THE European party of delegates to the World Engineering Congress, enroute to Tokio, stopped in Washington, D. C., October 2 and 3. A committee of prominent engineers in Washington, lead by L. W. Wallace, executive secretary, American Engineering Council, was in charge of their entertainment in the Capitol. The visitors were taken on trips to Mount Vernon, through principal government buildings and to other points of interest about the city. Joined by delegates to the Congress from the eastern part of the United States they were dined by his excellency Katsuji Debuchi, Japanese ambassador to the United States, and received at the White House. President Hoover is one of the progenitors of the World Engineering Congress and is honorary chairman of its American Committee.

On the trip, further stopovers were scheduled for Chicago, Los Angeles, San Francisco and Hawaii.

H. B. Walker, chief of the division of agricultural engineering, University of California, and representative of the American Society of Agricultural Engineers at the Congress, left San Francisco with the official party sailing for Tokio on the President Jackson and Korea Maru, October 10. His paper before the Congress is published elsewhere in this issue.

The Congress convened in Tokio October 29 and is to continue with about two weeks of sessions, interspersed and followed by trips to places and engineering works of interest in various parts of Japan.

North Atlantic Section Meeting Draws Record Attendance

ONE hundred eleven agricultural engineers registered for the sixth annual meeting of the North Atlantic Section, of the American Society of Agricultural Engineers, at Amherst, Massachusetts, October 17, 18 and 19. They came mostly from the thirteen original states and the eastern provinces of Canada which are within the boundaries of the Section.

This was the first three-day meeting ever attempted by the Section. The program, as developed by B. B. Robb and published in AGRICULTURAL ENGINEERING for October, the scenic and historic attractions of Massachusetts, the record attendance, and the arrangements made by the local committee under the leadership of C. I. Gunness were factors in its success.

Elected for the following year were R. W. Carpenter, University of Maryland, to be chairman of the Section; B. B. Robb, Cornell University, vice-chairman; O. B. Stichter, Louden Machinery Company, secretary-treasurer; and on the nominating committee, W. C. Harrington, Portland Cement Association, L. G. Heimpel, Macdonald College (Quebec), and C. E. Seitz, Virginia Polytechnic Institute.

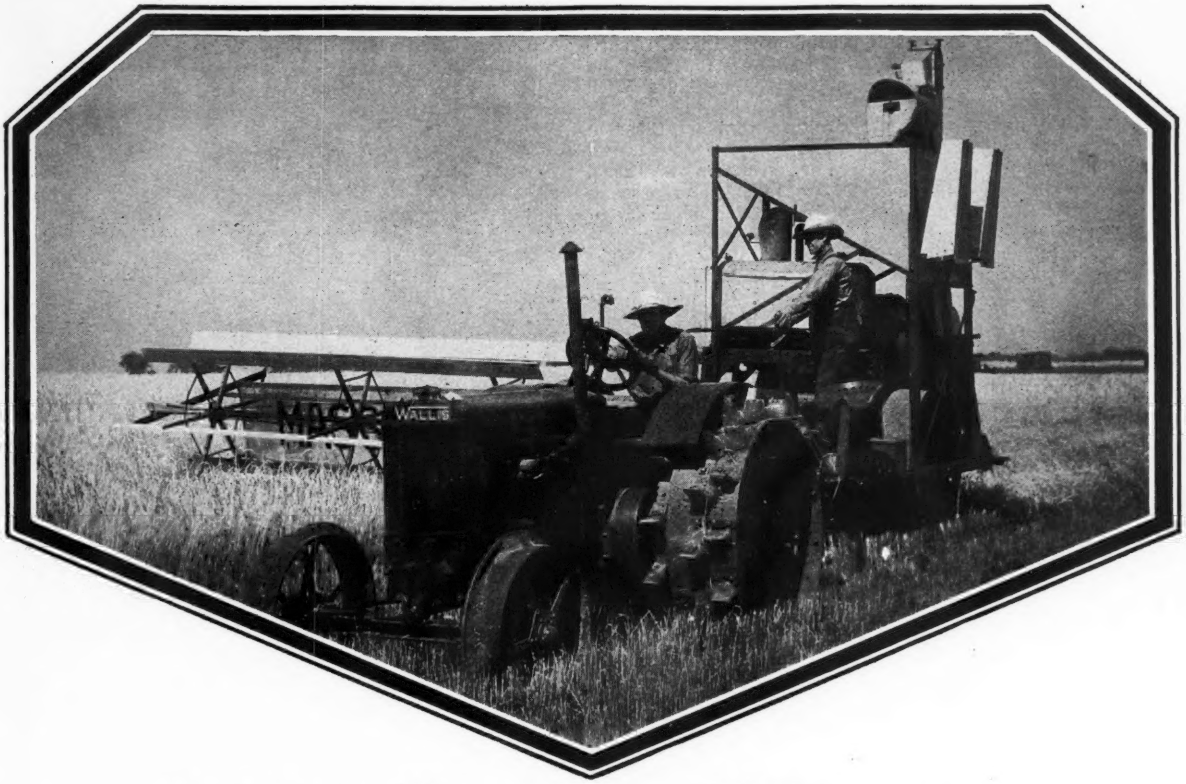
Rochester, N. Y., was chosen for the meeting place next year. The date of that meeting will be set at some time in the future.

Personals of A.S.A.E. Members

Hobart Beresford, head of the department of agricultural engineering, University of Idaho, is co-author with poultry department specialists of the University of Extension Bulletin No. 75, entitled "Housing Farm Poultry."

F. W. Duffee and J. P. Schaenzer are joint authors of Wisconsin Extension Circular No. 229 entitled "Turn on the Water."

C. L. Hamilton, formerly instructor in agricultural engineering at the University of Saskatchewan, has resigned this position to take charge of extension work in agricultural engineering for North Dakota Agricultural College.



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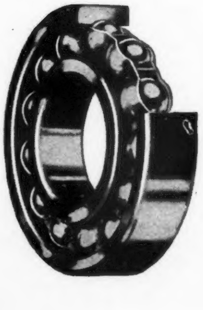

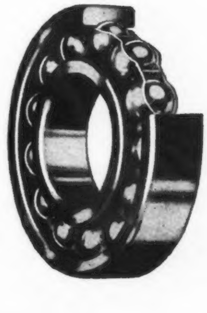

NEW DEPARTURE
BALL BEARINGS

1325

J. K. MacKenzie, assistant superintendent, Dominion Experimental Station, Swift Current, Saskatchewan, is co-author with J. G. Taggert of Dominion of Canada, Department of Agriculture Bulletin No. 118-New Series. The title of the bulletin is "Seven Years' Experience With the Combined Reaper-Thresher, 1922-1928."

J. T. McAlister, extension agricultural engineer, Clemson Agricultural College, attended the meeting of the southern section of the American Society of Agronomy at Athens, Georgia, August 28, 29, and 30, as the official representative of the Southern Section of the American Society of Agricultural Engineers.

John Q. McDonald is in Russia in the interest of the Caterpillar Tractor Company. His headquarters are the Savoy Hotel, Moscow. He expects to be there for about a year.

W. L. Ruden has been appointed to take charge of farm mechanics instruction in the Salinas High School, Salinas, California, resigning as a member of the agricultural engineering staff of the University of California.

H. P. Smith, associate professor of agricultural engineering, A. & M. College of Texas, is the author of a new textbook, entitled "Farm Machinery and Equipment," published by McGraw-Hill Book Company, New York, N.Y.

Verne W. Stambaugh, until recently state irrigation engineer, Division of Water Resources, Kansas State Board of Agriculture, is now employed as rural service engineer with the Public Service Company of Colorado, Fort Collins, in charge of their newly organized rural service department.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of thhe October issue of AGRICULTURAL ENGINEERING Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

James K. Alvis, agricultural sales, Caterpillar Tractor Co., Peoria, Ill.

Edward A. Cockey, Jr., manager, Worthington Valley Farms, Cockeysville, Md.

Joseph E. Cress, research fellow, University of Idaho, Moscow, Ida.

Albert V. Krewatch, electrical engineer, National Rural Electric Project, College Park, Md.

Rene Hauzeur, writer, Carresa 9, No. 490, Chapinero, Bogota, Colombia, So. Am.

Howell E. Lacy, research engineer, Georgia State College of Agriculture, Athens, Ga.

Daryl B. Leonard, agricultural agent, Pacific Power & Light Co., Walla Walla, Wash.

Paul V. Morrissey, agricultural sales department, Caterpillar Tractor Co., Peoria, Ill.

C. V. Phagan, assistant extension agricultural engineer, Oklahoma A. & M. College, Stillwater, Okla.

Burwell B. Powell, economist and sociologist, National Rural Electric Project, College Park, Md.

Wilhelm Vutz, designer, J. I. Case Company, Racine Wis.

Henry C. Yawn, Jr., industrial engineer, Pearl River Valley Lumber Co., Hammond, La.

Transfer of Grade

E. L. Ocock, instructor, Northwest School and Station, University of Minnesota, Crookston, Minn. (Student to Junior Member.)

New A.S.A.E. Members

Carl V. Englund, farm field man, Portland Cement Association, Denver, Colo.

Kirk Fox, editor, Meredith Publishing Co., Des Moines, Ia.

C. T. Colley, The South Coast Co., Houma, La.

Lester W. Garver, assistant in sales department, Massey-Harris Co., Columbus, Ohio.

Robert R. Graham, professor of agricultural engineering, Ontario Agricultural College, Guelph, Ontario, Can.

Robert T. Harrison, county agricultural agent, Harlan, Ky.

Charles J. Hutchinson, farm engineering specialist, Louisiana State University, Baton Rouge, La.

Nicholas V. Kapercev, manager, United Slavish Agricultural Bureau, Chicago, Ill.

John S. Mack, president, G. C. Murphy Co., McKeesport, Pa.

Charles A. Marsh, ventilation engineer, Louden Machinery Co., Fairfield, Ia.

Earl R. Ohmes, farm advisor, The American Rolling Mill Co., Middletown, Ohio.

John A. Slipher, assistant professor of soils, Ohio State University, Columbus, Ohio.

Dwight D. Smith, research instructor, University of Missouri, Columbia, Mo.

Miguel Y. Solorzano, technical sub-director of reclamation service, Mexican Government, Agriculture & Credit Bank, Mexico City, Mex.

Leon F. Swartz, rural service engineer, Illinois Power and Light Corp., Bloomington, Ill.

Frank M. Wigsten, rural service director, Central Hudson Gas & Electric Corp., Poughkeeepsie, N. Y.

Joseph P. Windham, farm manager, Florida Power & Light Co., Miami, Fla.

Transfer of Grade

J. H. Fulmer, farmer, Green Acre Farms, Nazareth, Pa. (Associate to Full Member.)

John Scholten, instructor, University of Idaho, Moscow, Ida. (Student to Junior Member.)

Employment Bulletin

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available' section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Positions Open

AGRICULTURAL ENGINEER, with masters degree in agricultural engineering, wanted by a university in the Mississippi Valley, as assistant professor to handle research and some teaching in farm equipment. Salary depends on training and experience. PO-163.

AGRICULTURAL ENGINEER, preferably a recent graduate, with agricultural background and a bent for journalism, wanted by a large manufacturer of farm equipment for promotion work. Position must be filled in the near future. PO-164.

WRITER, with farm experience; agricultural engineering background an asset. Applicant should be capable of preparing feature stories for farm papers. In replying, please furnish samples of work. PO-165.

Men Available

AGRICULTURAL ENGINEER, graduate of a French university and a well known automotive school in the East, American citizen, single, age 31, specialized in selling tractors, agricultural implements, and automobiles, speaks fluent French, English and Near-Eastern languages, also working knowledge of Spanish, extensively traveled in Europe, desires making connection with a concern in their export department. Willing to go anywhere. MA-166.